ANNUAL REPORT

OF THE

SECRETARY OF WAR

ON THE

OPERATIONS OF THE DEPARTMENT

FOR THE

FISCAL YEAR ENDING JUNE 30, 1877.

VOLUME II.
PART I.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1877.

1878, Oct. 4.

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REPORT

OF

THE CHIEF OF ENGINEERS.

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OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., October 12, 1877.

SIR: I have the honor to present for your information the following report upon the duties and operations of the Engineer Department for the fiscal year ending June 30, 1877:

OFFICERS OF THE CORPS OF ENGINEERS.

The number of officers holding commissions in the Corps of Engineers, United States Army, at the end of the fiscal year was 109 on the active-list and 5 on the retired-list, the latter, however, under the law of January 21, 1870, not being available for duty. In the duties devolving upon the corps by law and by its organization, the employment of a number of scientists and assistant engineers has been necessary.

Since my last report the corps has lost by death one of its officers, First Lieut. John H. Weeden, who died at San Francisco, Cal., January 29, 1877.

There have been added to the corps, by promotion of graduates of the Military Academy, three second lieutenants, whose commissions date from June 15, 1877.

On the 30th June, 1877, the officers were distributed as follows:

On duty, office of the Chief of Engineers, including chief	4
On duty, office of the Chief of Engineers, and public buildings and grounds, District of Columbia	1
On duty, projection and construction of fortifications	5
On duty, construction of fortifications and light-house duty	2
On duty, construction of fortifications and river and harbor works and surveys for same	19
On duty, construction of fortifications and river and harbor works and light-house duty and surveys for same	3
On duty, construction of river and harbor works and surveys for same	19
On duty, construction of river and harbor works and light-house duty and surveys for same	6
On duty, survey of northern and northwestern lakes, and survey of the Mississippi River	4
On duty, inspection of jetties at mouth of Mississippi River	1
On duty, explorations of country west of one hundredth meridian	4
On duty with battalion of engineers	10
On duty with battalion of engineers and at the Military Academy	2
Detached on duty with the General of the Army, generals commanding divisions and departments, light-house establishment, Military Academy, Department of State, and the Board of Commissioners of the District of Columbia	23
On leave of absence	3
Recent graduates of the Military Academy on leave of absence	3
Total	109

SEA-COAST AND LAKE-FRONTIER DEFENSES.

During the past year, on account of the limited appropriations granted, work upon our sea-coast defenses has been practically limited to their care, preservation, and partial repair.

The urgent need for the preparation of our chief harbors for successful resistance to the powerful iron-clad fleets of the present day has been frequently presented in the annual reports and other papers of this office. Referring to these papers, in which the necessity for this preparation in advance of the emergency has been explained in detail, I again urge the adoption of some reasonable system of annual expenditure upon our harbor defenses.

For detailed report upon the several works of fortification, I beg leave to refer to the synopsis of reports of the several officers in charge. The estimates for the works have been carefully revised by me, and are earnestly recommended.

Special attention is asked to the estimate of $100,000 for torpedoes. This most valuable invention of modern warfare is used to form an obstruction and obstacle to the entrance of our harbors, and to hold the enemy's vessels under the fire of the shore batteries. The charges in the torpedoes are fired by the electric current, and many parts of the system cannot be obtained in an emergency. It is to procure and store such portions of the apparatus as cannot be speedily obtained, in the event of sudden hostilities, that the appropriation is asked.

FORTIFICATIONS.

Fort Wayne, Michigan, in charge of Lieut. Col. C. E. Blunt, Corps of Engineers.—This work commands the channel of Detroit River, and with its exterior barbette batteries already planned will control the navigation of that stream.

This work remains in the same condition as at the close of last year. The exterior batteries are unfinished, and the pointing and drainage of the scarps of the main work have not been taken in hand for want of funds.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Fort Porter, Black Rock, near Buffalo, N. Y., in charge of Lieut. Col. C. E. Blunt, Corps of Engineers.—This work occupies an important strategic point for the defense of the northern frontier.

This work remains in the same condition as reported last year. The adjoining grounds, which form part of the park system of the city of Buffalo, have been further improved by the city under authority of the act of Congress, July 11, 1870.

No appropriation was made for the fiscal year ending June 30, 1868.
No appropriation asked for next fiscal year.

Fort Niagara, mouth of Niagara River, New York, in charge of Maj. Walter McFarland, Corps of Engineers.—This work is situated at the mouth of the Niagara River, commanding its *debouch* into Lake Ontario.

This work remains in the same condition as at the close of the preceding fiscal year. Nothing has been done here except to construct a new road to the fort, the old one being nearly destroyed by washing away.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Fort Ontario, mouth of Oswego River, New York, in charge of Maj. Walter McFarland, Corps of Engineers.—This work protects the city of Oswego from a sudden attack or *coup de main*, or the levy of a contribution by a small force of an enemy on shipboard.

This work remains in the same condition as at the close of the last fiscal year. The masonry scarp of only one front, including bastions D and E, is high enough to be secure against a sudden assault. The faces of the remaining bastions have but an average of 12 or 14 feet of masonry above the bottom of the ditches, while the masonry of their flanks is but 4 or 5 feet above the bottom of the ditch, giving such facility of entrance into the work that a small guard, such as is usually left in the work when the garrison is called away, would be incapable of keeping out even a small body of men who might attempt to seize the ammunition and stores deposited there. This masonry scarp is not exposed to the direct fire of artillery and should be completed without further delay, or a stockade should be built over the low masonry.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Fort Montgomery, outlet to Lake Champlain, New York, in charge of Lieut. Col. John Newton, Corps of Engineers, until April 21, 1877; *since that date in charge of Capt. James Mercur, Corps of Engineers.*—This work occupies an important strategic point, and commands the entrance to Lake Champlain from the Richelieu or Saint John River.

Portions of the earthen parapet have been resodded, repairs made to the asphalt covering of curtain III, and tie-rods for strengthening the right or north face of bastion D have been put in.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Fort Knox, Bucksport, Penobscot River, Maine, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This work, situated at the narrows of the Penobscot River, furnishes a defense for the city of Bangor, 18 miles above, and other towns bordering the river, and renders it available as a secure harbor of refuge for the shipping of the extensive eastern coast.

The condition of this work remains unchanged, no operations having been carried on during the fiscal year except for the necessary care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Fort Popham, Kennebec River, Maine, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This work defends the entrance through the mouth of the Kennebec River to the rich valley of this river, the cities of Bath and Augusta, and the United States arsenal at the latter place.

The condition of this work remains unchanged, no operations having been carried on during the fiscal year except for the necessary care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Fort Gorges, Portland Harbor, Maine, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This work is one of the series of forts designed to defend the harbor and channels leading into the harbor of the important strategic position occupied by the city of Portland.

The condition of this work remains unchanged, no operations having

been carried on during the fiscal year except for the necessary care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $10,000 00

Fort Preble, Portland Harbor, Maine, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This work occupies such a position that three-fourths of its guns command the two principal channels entering the harbor of Portland.

The condition of this work remains unchanged, no operations having been carried on during the fiscal year except for the necessary care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $30,000 00

Fort Scammel, Portland Harbor, Maine, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This work occupies a very important position in the harbor and commands four of the channels leading into it.

The condition of this work remains unchanged, no operations having been carried on during the fiscal year except for the care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $50,000 00

Battery on Portland Head, Portland Harbor, Maine, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This work covers by its guns all the approaches to the main channel leading into the harbor, and will prevent by its fire an enemy's fleet from taking up, unopposed, a position behind Bangs's Island, from which to bombard Portland, or shell the shipping in the harbor.

The condition of this work remains the same as at the close of the last fiscal year, no operations having been carried on except for the necessary care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $50,000 00

Fort McClary, Portsmouth Harbor, New Hampshire, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This work, together with Fort Constitution, opposite, forms the inner line of defense to the mouth of the Piscataqua River, and to the navy-yard at Kittery, Maine.

The condition of this work remains the same as at the close of the previous fiscal year, no operations having been carried on except for the necessary care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Fort Constitution, Portsmouth Harbor, New Hampshire, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—The condition of this work remains unchanged, no operations having been carried on except for the necessary care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Battery on Gerrish's Island, Portsmouth Harbor, New Hampshire, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—This battery, with the one opposite, on Jerry's Point, forms the outer line of defense to Portsmouth Harbor, and to the navy-yard at Kittery, Maine.

This work remains the same as at the close of the last fiscal year, no operations having been carried on except for the necessary care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $36,000 00

Battery on Jerry's Point, Portsmouth Harbor, New Hampshire, in charge of Lieut. Col. J. C. Duane, Corps of Engineers.—No operations were carried on at this work during the past fiscal year except for the necessary care and preservation of the property.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $24,000 00

Fort Warren, Boston Harbor, Massachusetts, in charge of Col. Henry. W. Benham, Corps of Engineers.—This important work is for the defense of the main channel of entrance to Boston Harbor, and commands the anchorage of Nantasket Roads.

The small amount of funds available was expended during the working season of 1876 in repairing the earth-slopes of the ravelin battery, of the cover-face of front 3, and of bastion A; in repairs to the concrete and plastering of the magazine-arch in bastion B, to the main drain in the ditch of front 2, and to the asphalt cover of the casemates of front 3

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $75,000 00

Battery at Long Island Head, Boston Harbor, Massachusetts, in charge of Col. Henry W. Benham, Corps of Engineers.—This work occupies an important position in the outer line of defense to Boston Harbor, and its guns bear upon all the channels of entrance thereto.

During the past fiscal year repairs were made to the drains, and the terrepleins of the two upper batteries were graded sufficiently to allow the guns to be traversed.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $50,000 00

Fort Winthrop, Boston Harbor, Massachusetts, in charge of Col. Henry W. Benham, Corps of Engineers.—This is one of the works forming the inner line of defense to Boston Harbor and the navy-yard at Charlestown.

Operations during the whole year were confined, from want of funds, to a few slight repairs to the slopes and drains. The work is generally in good condition, but small sea-walls are required to protect the sites of the east and south batteries.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $50,000 00

Fort Independence, Boston Harbor, Massachusetts, in charge of Col. Henry W. Benham, Corps of Engineers.—This is one of the works forming the inner line of defense for the harbor of Boston.

Work was suspended during the whole year from want of funds, the small balance available being expended in the care and oversight of the work.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $30,000 00

Fort at Clark's Point, New Bedford Harbor, Massachusetts, in charge of Maj. G. K. Warren, Corps of Engineers.—The guns of this work command the entrance to the harbor of New Bedford.

Nothing has been done during the past fiscal year except taking care of the property.

Plans for the heavy-gun batteries are ready, and work can be begun as soon as money is appropriated.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $30,000 00

Fort Adams, Newport Harbor, Rhode Island, in charge of Maj. G. K. Warren, Corps of Engineers.—This large and important work defends

the harbor and city of Newport, and commands the principal passage to Narragansett Bay, one of the best roadsteads on the coast.

Nothing has been done during the fiscal year excepting for the care and preservation of the work.

The preparatory work for the construction of the new battery (such as draining and opening of roads) having been completed, rapid progress can be made in construction when the necessary funds are appropriated.

Many repairs are needed to the main work and to the permanent wharf.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $40,000 00

Defenses of Dutch Island, western entrance to Narragansett Bay, Rhode Island, in charge of Maj. G. K. Warren, Corps of Engineers.—These defenses lie in and command the western passage to Narragansett Bay.

The only work performed during the fiscal year has been the general care of the property.

No other work is contemplated for the fiscal year ending June 30, 1878.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $40,000 00

Fort Trumbull, New London Harbor, Connecticut, in charge of Maj. J. W. Barlow, Corps of Engineers.—This work, upon the west bank of the Thames River, with Battery Griswold on the east bank, forms the defense of the harbor of New London.

Operations have been confined to the repair and preservation of the work. An appropriation for building the south exterior battery is recommended.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $40,000 00

Fort Griswold, New London Harbor, Connecticut, in charge of Maj. J. W. Barlow, Corps of Engineers.—During the past fiscal year the boundaries of the United States property have been established, and merestones marking the lines have been replaced.

The stone fences should be repaired and made to conform to the established boundaries.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Fort Hale, New Haven Harbor, Connecticut, in charge of Maj. J. W. Barlow, Corps of Engineers.—This work commands the channel of entrance to New Haven Harbor.

No work has been done during the past fiscal year. The sea-wall has sustained additional damage from the action of ice and storms. To rebuild wall on old plan and repair the break in the beach would cost $2,000. To rebuild wall upon the new plan submitted by the officer in charge, including repair of break, would cost $10,000.

The expediency of these repairs is under consideration by the Board of Engineers for Fortifications.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Fort Schuyler, East River, New York, in charge of Maj. H. L. Abbot, Corps of Engineers.—This is an important work for the defense of the entrance to the harbor of New York City through the East River.

Nothing more than the ordinary care of the property has been possible during the year, owing to want of funds.

The main work is in a state which urgently requires attention. The remodeling of the barbette tier, to enable it to receive its proposed ar-

mament of modern guns, has been mainly finished, but was suddenly stopped by the failure of the appropriation, and the new part now deteriorates under the action of the weather.

This fact, and the vast importance of the work to the defense of New York Harbor, renders a liberal appropriation specially needed.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $50,000 00

Fort at Willets Point, eastern entrance to New York Harbor, in charge of Maj. H. L. Abbot, Corps of Engineers.—This work unites with Fort Schuyler in the defense of the entrance to the harbor of New York City through the East River.

Want of funds has prevented any essential progress from being made in preparing this important position for use in defending New York City in case of war. Now that the Hell-Gate Channel is rapidly improving, and the city is extending along East River, the preparation of a strong defensive line for excluding a hostile fleet with certainty from these waters is a matter of the very first importance. Torpedoes would, of course, be made to play an important part, but shore batteries are essential to defend them against the counter-operations of an enemy; and when the safety of such a port as New York is concerned, the necessary preparation should not be delayed.

During the past fiscal year the sea-wall for the protection of the east battery has been extended 212 linear feet. The slopes and traverse magazines of this battery, which had been badly washed in consequence of the want of funds for the necessary sodding, have been regraded and partially protected by placing 2,237 superficial yards of sod. Storage-casemates have been covered with 1,550 cubic yards of earth, nearly to grade. The wharf has been strengthened by the addition of 148 piles, rendered necessary by injuries from marine worms. The ordinary repairs of the different batteries and the care of the property have consumed the rest of the funds available.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next year $30,000 00

Fort Columbus, Governor's Island, New York Harbor, in charge of Lieut. Col. John Newton, Corps of Engineers, until April 21, 1877; since that date in charge of Capt. James Mercur, Corps of Engineers.—The only work done during the past fiscal year consisted in extensive repairs to the engineer wharf.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $5,000 00

New Barbette Battery at Fort Columbus, Governor's Island, New York Harbor, in charge of Lieut. Col. John Newton, Corps of Engineers, until April 21, 1877; since that date in charge of Capt. James Mercur, Corps of Engineers.—No work was done here during the past fiscal year, and none contemplated during the present year.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Castle Williams, Governor's Island, New York Harbor, in charge of Lieut. Col. John Newton, Corps of Engineers, until April 21, 1877; since that date in charge of Capt. James Mercur, Corps of Engineers.—No work was done here during the last fiscal year.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

South Battery, Governor's Island, New York Harbor, in charge of Lieut. Col. John Newton, Corps of Engineers, until April 21, 1877; since that

date in charge of Capt. James Mercur, Corps of Engineers.—No work was done here during the past fiscal year, and none contemplated during the present.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Fort Wood, Bedloe's Island, New York Harbor, in charge of Lieut. Col. John Newton, Corps of Engineers, until April 21, 1877; *since that date in charge of Capt. James Mercur, Corps of Engineers.*—This work, together with those upon Governor's Island, is designed to close the entrance to the East and Hudson rivers, and to cover New York, part of Brooklyn, and Jersey City from bombardment.

No work has been done on this fort during the past fiscal year. Application was made in February, 1877, by Henry W. de Stuckle, esq., on behalf of the Union Franco-Americaine, for plans and designs of a site for the pedestal of the colossal statue of Liberty.

By a resolution of Congress approved March 3, 1877, the President was authorized to accept the colossal statue of "Liberty enlightening the World" when presented by the citizens of the French Republic, and to designate and set apart for the erection thereof a suitable site upon either Governor's or Bedloe's Island, in the harbor of New York. By authority of the Honorable the Secretary of War the erection of the statue on the parade of the work was authorized, and a plan of the site was furnished Mr. de Stuckle in April last, but as yet no operations have been commenced on the part of the Union Franco-Americaine.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Fort Hamilton and additional batteries, New York Harbor, in charge of Lieut. Col. John Newton, Corps of Engineers, until April 21, 1877; *since that date in charge of Capt. James Mercur, Corps of Engineers.*—These works are situated at the Narrows of New York Harbor, upon the Long Island side.

During the past fiscal year repairs were made to the gates and barriers leading to the main ditch of the main work, and to the sodding of the slopes and magazines of the 15-inch-gun battery.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Mortar-Battery at Fort Hamilton, New York Harbor, in charge of Lieut. Col. John Newton, Corps of Engineers, until April 21, 1877; *since that date in charge of Capt. James Mercur, Corps of Engineers.*—No operations were carried on during the past fiscal year.

Fort Wadsworth, Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This fort, situated on the Staten Island side of the Narrows of New York Harbor, is a large casemated work, having its lower tier of guns only a few feet above the level of ordinary high water.

The ditch requires cleaning out, some painting and pointing are needed, and shot-beds are wanted on the parade of the work. It is also very desirable that the reservoir of spring-water in the ditch of the work should be covered over, as it is becoming filled with a vegetable growth—probably a species of *bacteria*—which may ultimately render the water unfit for use. As this plant requires light for its generation and growth, it would doubtless disappear if the reservoir were covered.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $9,000 00

Fort on site of Fort Tompkins, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work crowns the hill in rear of Fort Wadsworth and the open batteries on Staten Island, and is designed to accommodate the garrisons and act as a keep for those works. When completed it will be able to throw a heavy fire from a commanding position upon vessels attempting to pass through the Narrows.

It has been in readiness to receive its armament for some years. For want of funds, the operations during the past fiscal year have been restricted, with the exceptions noted below, to repairs of the earthwork and roads, to cutting the grass on the slopes, keeping a supply of water in the distributing-reservoir located on the glacis, and other necessary repairs and improvement of the work of a small kind.

Some portions of the long slope leading down to Fort Wadsworth have been regraded and sodded.

No operations can be carried on during the present fiscal year for want of funds. Attention has been called in former reports to the bad condition of the large slope in front of the channel-face of this work, and an appropriation for completing it is again earnestly recommended.

The estimates for completing this work, the glacis gun-battery, and the North Cliff and South Cliff batteries, contemplate the following work not previously estimated for, viz: Constructing and laying 21 stone platforms in place of the timber platforms now in position; lining with wood 14 principal magazines never yet lined; providing bonnets and the necessary wing-walls for the traverses on the channel-front of Fort Tompkins and in the North Cliff battery; building rough sea-walls at the foot of the exterior slopes of both the North Cliff and South Cliff batteries to protect them from wash, and thickening the parapets of these batteries. It has also been found necessary to increase the estimate for grading the long slope in front of Fort Tompkins, to provide for the damage caused by exposure and delay.

Amount (estimated) required for completing Fort Tompkins, the glacis gun-battery, and the North Cliff and South Cliff batteries, $170,000.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year to continue the work, the glacis gun-battery, and the North Cliff and South Cliff batteries.................... $75,000 00

Glacis Gun-Battery, (north of fort on site of Fort Tompkins,) Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This battery has been in readiness to receive its armament for the last four years. Some little work yet remains to be done to the magazine-doors and lamp-closets. No work was done during the last fiscal year except to cut the grass from the slopes, and repair minor damages to the same.

The cost of substituting stone for timber platforms, amounting to about $9,000, is included in the estimate for Fort Tompkins.

No separate appropriation asked for this work.

Glacis Mortar-Battery, (south of fort on site of Fort Tompkins,) Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This battery and its armament are ready for service. During the past fiscal year portions of the slopes damaged by heavy rains have been repaired and resodded. A little work yet remains to be done upon the lamp-closets, and the principal magazine requires to be furred off.

No appropriation asked for next fiscal year.

Battery Hudson, Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work and the North Cliff and South Cliff batteries occupy the slope between Fort Tompkins and the water, and are able to bring a powerful fire upon the channel leading up to and through the Narrows.

During the last fiscal year the outer traverse-rails have been laid on permanent platforms, Nos. 2 and 3, on the eastern face of the battery, and the parapets on this, as well as on the southern face, have been strengthened and repaired. In the extension of the battery the earthwork of the parapet has been roughly formed. The outer iron traverse-rails have been laid on the five 15-inch-gun timber platforms in the extension. All the earthen slopes have been kept well dressed and in a tolerably good state of preservation. There has been no change in the armament during the year.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $24,000 00

South Mortar-Battery, (in rear of Battery Hudson extension,) Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—The work necessary for the completion of this battery consists in constructing and laying eight timber mortar-platforms upon concrete foundations, now in place, in fitting up the inner magazine-doors and two lamp-closets. No platforms are finished.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $9,000 00

North Cliff Battery, Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—No work beyond some necessary repairs was carried on at this battery during the past fiscal year for want of funds, and there has been no change in its armament.

The cost of completing the battery, by substituting six stone gun-platforms for those of timber, constructing six stone breast-height walls, two bonnets on the traverses, lining the two principal magazines with timber, thickening the parapet, and constructing a rough sea-wall at the foot of the exterior slope, amounting in the aggregate to $34,700, is included in the estimate for fort on site of Fort Tompkins.

No separate appropriation asked for next fiscal year.

South Cliff Battery, Staten Island, New York Harbor, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—With the exception of slight repairs no work was done in this battery during the past fiscal year for want of funds. There has been no change in the armament during the year.

The cost of completing the battery in accordance with the approved plan, including the thickening of the parapet, a rough sea-wall at the foot of the exterior slope, and wooden linings in the principal magazines, amounting in the whole to $37,100, is included in the estimate for fort on site of Fort Tompkins.

No separate appropriation is asked for next fiscal year.

Fort at Sandy Hook, New Jersey, in charge of Lieut. Col. John Newton, Corps of Engineers, until April 21, 1877; since that date in charge of Capt. James Mercur, Corps of Engineers.—One of the great objects of this work is to prevent the occupation of the lower bay as an anchorage by an enemy's fleets.

No work was done during the past year, except slight repairs to the jetties.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Fort Mifflin, Delaware River, Pennsylvania, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers.—This fort constitutes one of the inner line of works for the defense of Philadelphia and the naval establishment at League Island.

Except making minor requisite repairs to the front dike and wall near main sluice during the past year, the condition of the work remains the same as at the close of the previous fiscal year. No appropriation having been made for the present fiscal year, the work will continue in care of a fort-keeper.

During the next fiscal year it is proposed to construct the torpedo casemate-gallery, complete the exterior battery, construct battery north face of demilune, construct battery on south face main work, commence construction of storage-magazine exterior battery, and make necessary repairs to dikes, roads, &c.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $75,000 00

Mortar-Battery at Fort Mifflin, Delaware River, Pennsylvania, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers.—No work has been done at this battery during the past year for the want of funds, and none is proposed for the present fiscal year for the same reason.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Site for the defenses at Red Bank, New Jersey, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers.—This site is upon the New Jersey side of the Delaware River, nearly opposite Fort Mifflin, and is in care of a property-keeper.

During the past year material repairs have been made to the dike along the south boundary; the buildings and fences have received slight repairs. It is proposed, during the present year, to place additional rock revetment along the river-slope of the dike, make needed repairs to the buildings and fences, and exercise the usual care over the site and other public property.

No appropriation has yet been made for a battery on this site.
No appropriation asked for next fiscal year.

Fort Delaware, Delaware River, Delaware, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers.—This work, situated on the Pea Patch Island, forms one of the chain of works constituting the outer line of defense for the Delaware River.

The damages to the southern wharf and to the dike at the south end of the island, caused by the severe storm of September last, have been repaired. It has also been found necessary to repair, temporarily, what remains of the old work of the upper eastern wharf, in order to protect it and the unfinished stone masonry of the new superstructure, until work is resumed. The fort and grounds have been kept in as good order as the limited means would allow.

The work proposed for the next fiscal year is to give increased protection to the magazines, to construct torpedo-casemate, to repair tide-gates of ditches, southern wharf, counterscarp, temporary buildings, and bridges, and to continue superstructure of eastern wharf.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $75,000 00

Battery at Finn's Point, Delaware River, New Jersey, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers.—This is a powerful earthen barbette battery, and forms the left of the outer line of defenses across the mouth of the Delaware River.

During the year two partly constructed stone gun-platforms have been completed; repairs to the sea-wall below the wharf have been finished, and a jetty has been thrown out from its southern extremity; some additional protection has been given to the sea-wall in front and south of the mortar battery; a small portion of breast-height wall has been repointed, and the sodded slopes of the battery have been kept in order.

The work proposed for next fiscal year is to construct six stone gun-platforms and the breast-height wall in front; to build three magazines with their covering-traverses, and to complete the traverse of the magazine last finished; to build the passage-way from wharf through the battery, and to continue the embankment of the battery and construction of sea-wall.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $50,000 00

Mortar Battery at Finn's Point, Delaware River, New Jersey, in charge of Lieut. Colonel J. D. Kurtz, Corps of Engineers.—No operations were carried on at this work during the past year for want of funds, and none are contemplated for the present year. Its condition remains the same as at the date of the last annual report.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Fort opposite Fort Delaware, Delaware shore, in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers.—A strong earthen barbette-battery, forming the right of the outer line of defenses for the Delaware River.

Operations at this work, beyond the care and preservation of public property, have been of little importance. The preparation of stone for the two gun-platforms, commenced last year, has been completed, and the two pintle-stones have been set. Some repairs have been made to the dike on the river-front.

During the next fiscal year, if funds are provided, it is proposed to construct six gun-platforms with the breast-height wall in front, and to finish the two already commenced; to build three magazines with their covering-traverses; to complete torpedo-cable gallery, and to continue the embankment of the gallery.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $75,000 00

Mortar Battery near Delaware City, Del., in charge of Lieut. Col. J. D. Kurtz, Corps of Engineers.—The two unfinished magazines of this work have been completed; the covering-traverses have been embanked to nearly their full height, and the parapet in front has been raised to 9 feet above the terre-plein. During the next fiscal year it is proposed, if funds are provided, to finish this work by constructing the magazine on the right, completing the parapet and traverses, and laying platforms for six mortars.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Fort McHenry, Baltimore Harbor, Maryland, in charge of Maj. William P. Craighill, Corps of Engineers.—This fort forms part of the inner line of defense for Baltimore and its dependent interests, and commands with its fire the interior waters of the harbor and the channel of approach thereto, in which latter a depth of 24 feet exists at mean low water.

The importance of this site has been set forth in previous annual reports. While the old fort (proper) has become almost useless as a defensive work, the water-front should still be occupied by a battery of

heavy guns mounted behind a sand parapet of the most approved model, and provided with boom-proof cover for ammunition and gunners. Such a battery is in course of construction. The condition in which this battery stood June 30, 1876, is given in the last annual report.

At the end of June, 1876, the appropriation of $20,000 which was made February 10, 1875, was very nearly exhausted; so nearly, that on the 8th of July, 1876, all work upon the exterior battery was suspended for want of funds, and the store-houses and other public property were placed in charge of a watchman.

The few days at the beginning of the fiscal year were devoted to the regrading of the terre-plein, and the placing of soil upon the slopes in rear of the battery to secure a growth of grass.

There being no appropriation for the fiscal year ending June 30, 1877, operations otherwise have been confined to some slight repairs to the slopes of the new battery and the fence in its rear, and to more extensive repairs to the wharf and the sea-wall about the site, which were badly damaged by the severe storm of the 17th and 18th of September, 1876. One hundred and twenty linear feet of the superstructure of the wharf at the shore end were carried away, leaving the piles and the head of the wharf intact. This superstructure was replaced during the month of October.

The sea-wall about the site was badly shaken up, especially on the most exposed (south) face. Repairs as extensive as funds would allow were made upon the wall during October and November, 1876.

At the close of November all the portable property pertaining to the work was moved to and stored at Fort Carroll, and the services of a watchman have since been dispensed with.

The sum of $50,000 is asked for the next fiscal year, which would nearly complete the parapet and terre-plein, including the magazines, but not the gun-platforms, which it is not deemed expedient to put down until after the embankments become well consolidated, on account of the unstable nature of the subsoil.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year.................................. $50,000 00

Fort Carroll, Baltimore Harbor, Maryland, in charge of Maj. William P. Craighill, Corps of Engineers.—This fort is situated upon an exterior line of defense for the harbor of Baltimore. It is a casemated work, but nothing has been done in the past year in carrying out the project for its completion, which contemplated the provision for three tiers of guns in casemates and one in barbette. This delay is due to the fact that the best method of arranging such defenses, consistent with a due regard to economy, has not yet been determined.

During the past year nothing has been done but what was necessary for preservation and care of property. This work consisted of repairs to fences and temporary wooden roofs over the masonry, which were damaged by high winds and heavy seas. The severe storm of September 17–18 entirely broke up the wooden cover in front of the 15-inch gun at the southwest salient, the high fence at the open (south) face was moved bodily inward, and about 20 linear feet of roofing destroyed. These damages were all repaired during the month of September. Subsequent storms having occasionally caused damage calling for frequent repairs, particularly to the roofs, it was determined to repair the latter thoroughly, putting in new rafters to replace the old ones which had become decayed. This was all accomplished during the month of June,

1877. There has been no change in the armament since the last annual report.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Obstructions of the Potomac, in charge of Maj. William P. Craighill, Corps of Engineers.—The material pertaining to these floating obstructions has continued in store at Fort Foote, in charge of a watchman. The timber portion of it has decayed very much, and is rapidly deteriorating in value.

An inspection of the building in which these obstructions are stored was made in October, 1876. It disclosed the necessity of repairing the pile foundation on which the building rests, and the repairs were at once made. The piles were thoroughly braced, and crib-work was substituted in the place of two piles which were entirely gone.

Fort Foote, Potomac River, Maryland, in charge of Maj. William P. Craighill, Corps of Engineers.—This work is on the inner line of defense of the channel of approach by water to Alexandria, Washington, and Georgetown. The site is high, commanding, and unusually favorable.

During the past fiscal year, for want of funds, nothing was attempted except some repairs of a limited extent. In October last the boundary lines of the site were run, and the corners marked with stone monuments with the letters U. S. inscribed thereon.

In June, 1877, two of the new front pintle 15-inch gun-platforms were provided with traverse-circles, and a temporary wooden breast-height built in front of them.

Attention is again urgently invited to the fact that the unfinished condition of this fort must render it liable to certain injury and deterioration, and to care for the work already done the modification of the main fort should be completed as soon as possible. Appropriation for this purpose is important.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year.................................. $50,000 00

Fort Washington, Potomac River, Maryland, in charge of Maj. William P. Craighill, Corps of Engineers.—This fort occupies a very important position on the outer line of defense of the cities of Alexandria, Washington, and Georgetown, and their dependent interests. The site is an excellent one, but the line requires strengthening by the introduction of guns of the heaviest caliber, for which the old fort was not suited.

There having been no specific appropriation for this work, operations during the past fiscal year have been confined to the general care and preservation of the property; to repairs of a limited extent to the wharf, to the bridge at main sally-port, and to the fences on and about the site, and to running out and marking the boundary-lines of the territory purchased and added to the site by the United States in 1875.

At the beginning of the fiscal year repairs upon the wharf were in progress. These repairs were completed in July, 1876.

Eighty linear feet of the crib-work on the south side of the wharf were replaced, and four new fender-piles were driven at the head of the wharf. The bridge at the main sally-port was strengthened in March last by putting in new stringers and planks.

During March and April last the fences along the road through the new purchase, as well as along the adjacent farms, were put in good condition.

In November, 1876, the boundary-lines of the new purchase were run,

and the corners marked with stone monuments with the letters U. S. inscribed thereon.

A revised project of defense for the site has been prepared and is now being considered by the Board of Engineers for Fortifications. While this is unfinished, no estimate for the completion of the work can be made.

Attention is again pressingly invited to the need of the appropriation asked for this fort. The portion of the work begun should be finished. It is daily suffering serious injury and deterioration, owing to its incomplete state. No change in armament since last annual report.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $50,000 00

Fort Monroe, Old Point Comfort, Virginia, temporarily in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This extensive work occupies an important position, covering the approach to Hampton Roads, the navy-yard at Portsmouth, and the James River.

During the past fiscal year, for want of funds, no work was done except what was necessary for the preservation of the work and the public property. The breakwater damaged by the storm in April last has been repaired, and backed with sand and rubble-stones for its entire length, (606 feet.)

The changes in the armament of the work comprise the dismounting of 10-inch Rodman guns from platforms 87, 88, 89, and 93, and 100-pounder Parrott rifles from platforms 91, 92, and 94, and the mounting of 8-inch converted rifle-guns on platforms 91, 92, 93, and 94, and 100-pounder Parrott rifles on platforms 87, 88, and 89. An increase of $5,000 in the amount previously estimated for completing the work will be required for placing bonnets on the traverses and increasing the length of breast-height walls in the redoubt and place of arms.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $75,000 00

Artesian well at Fort Monroe, Virginia, temporarily in charge of Lieut. Col. Q. A. Gillmore, Corps of Egineers.—No work was done during the last fiscal year, and none is contemplated during the present fiscal year for want of funds. The inadequate and uncertain supply of water at Fort Monroe is an evil which, it is conceded on all sides, may at any time arise to serious magnitude. The present depth of the well is about 900 feet. It is recommended that provision be made to increase this depth to 1,200, or even to 1,500 feet, before abandoning the project of obtaining a water-supply by this method.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $10,000 00

Fort Wool, Hampton Roads, Virginia, temporarily in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This casemated fortification unites with Fort Monroe in closing the passage to Hampton Roads, crossing its fire with the guns of that fort.

Until approved projects for its completion are devised no further work is contemplated than is necessary to preserve it from injury. Fifty-two iron-throated casemates of the first tier are ready for guns, and in an emergency several 15-inch guns could be advantageously and promptly mounted in barbette.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Fort Macon, Beaufort Harbor, North Carolina, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work is situated at the mouth of the harbor and defends the principal entrance thereto.

The subject of the modification of this work is still under consideration.

During the past fiscal year monthly measurements have been made of the position of the shore-line in the vicinity of the wharf.

No material change has occurred on this side of the beach. Serious encroachments were made on the shore-line of the south side during a storm on the 17th September, 1876, the four spur jetties having been laid bare and the sand-hills in rear of them along the beach having been washed away. Under the action of the jetties the shore-line is making out to its former position.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Fort Caswell, mouth of Cape Fear River, North Carolina, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—The subject of the modification of this work is still under consideration.

Its location is advantageous for the protection of one of the entrances to Cape Fear River, and therefore one of the approaches to the city of Wilmington.

There is neither armament nor garrison, nor quarters for a garrison, at the place.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Fort Moultrie, Charleston Harbor, South Carolina, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work is situated on Sullivan Island, and defends the principal entrance to the harbor of Charleston.

No work was done during the last fiscal year, except for the general preservation and repair of the work. Eight platforms, one permanent and seven timber, are in readiness for, but not occupied by, heavy guns. Four mortars are mounted in rear of the fort. The laying of the two timber platforms now on hand, in place of those now occupied by light guns, will complete the preparations for arming this work.

Estimated cost of completing the work, (including bonnets on the traverses, a soldiers' latrine, and draining the parade, not embraced in former estimate,) $89,000.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $50,000 00

Fort Sumter, Charleston Harbor, South Carolina, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work is located on a shoal near the mouth of the harbor on the south side, and its guns, crossing their fire with those of Fort Moultrie, command the principal channel of entrance thereto.

No operations were carried on at this work during the past fiscal year, except the storing of the timbers of platforms 9 and 10, the repairing of damage to slopes, caused by the severe storm of April 13, 1877, and the erection of a small breakwater on the old wharf opposite gorge front. One timber and three permanent platforms for heavy guns are ready, but not occupied. The replacing of the two platforms 9 and 10, now occupied by light guns, by heavy timber platforms, would make the work ready for its armament. The eleven casemates on northeast front are armed. The eight casemates on northwest front are now ready for their guns, except traverse circles. To the estimates for completing this work given in the last annual report there should be added the cost of putting bonnets on the traverses, arranging a room for torpedo

defense, and repairing and extending the existing wharf. With these additions the estimated cost of completing the work is $82,000.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $50,000 00

Fort Johnson, Charleston Harbor, South Carolina, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This fort, situated on James Island, is one of the works in the system of defense of Charleston Harbor.

No operations were carried on at this work during the past fiscal year. The approved project for reconstructing this old work contemplates making of it a battery for eight pieces of heavy ordnance, four mortars, and four guns. Its commencement and completion during the next fiscal year is recommended. Four 13-inch mortar platforms are on hand, ready to be laid.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $10,000 00

Castle Pinckney, Charleston Harbor, South Carolina, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work, situated on an island near the city of Charleston, is one of the works in the system of defense of the harbor.

No operations were carried on at this work during the past fiscal year. An appropriation is required to adapt it to the reception of 10-inch smooth-bore guns or corresponding rifles, to be mounted in barbette.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Fort Jackson, Savannah River, Georgia, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work, situated about four miles from the city of Savannah, forms the inner line of defense for that city.

No operations were carried on during the past fiscal year. Five guns are in position, but they are not of the calibers contemplated in the approved project, and cannot be efficiently served without a completion of the work. Estimated cost of completing the work, including repairs to wharf, $10,000.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $10,000 00

Fort Pulaski, mouth of Savannah River, Georgia, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This is the principal work for the defense of Savannah on the outer line of the system.

No operations were carried on at this work during the last fiscal year, except the cleaning out of the drains in the vicinity of the fort and cutting the grass from the slopes. Five timber platforms are now in readiness for, but not occupied by, heavy guns in the demilune.

Estimated cost of completing the work, including bonnets on the traverses, permanent platforms, and soldiers' latrine, $256,000.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $75,000 00

New Fort on Tybee Island, mouth of Savannah River, Georgia, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—Plans for the defensive works to be constructed on the north point of Tybee Island have been completed, and it is proposed to commence their construction whenever funds are available.

No appropriation for the work has yet been made.
No appropriation asked for next fiscal year.

Fort Clinch, Amelia Island, Florida, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work defends the entrance into Cumberland Sound, and is in an unfinished condition.

The slate roof of the brick barracks inside the fort was repaired during the past fiscal year. No other operations have been carried on during the year, the project for the modification of the work being still under consideration.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Fort Marion, Saint Augustine, Florida, in charge of Lieut. Col. Q. A. Gillmore, Corps of Engineers.—This work defends the harbor and city of Saint Augustine.

During the past fiscal year the only work done was to repair the temporary roof erected over the terre-plein of the north front, for the accommodation of Indian prisoners.

Fort Marion was built by the Spaniards, and was called by them Fort Saint Mark. It was essentially completed in the year 1756, its process of construction having extended through a period of more than one hundred years. It is built of coquina—a natural shell-concrete found in the vicinity. No money has been expended by the United States for the maintenance of the work, or in arresting the progress of ordinary deterioration and decay, for the reason, doubtless, that the water-battery, constructed in 1842–'43, will, if suitably armed, furnish a sufficient defense for this locality.

No appropriation is asked for this work.

Fort Taylor and batteries, Key West, Florida, in charge of Maj. Jared A. Smith, Corps of Engineers, until December 16, 1876; since that date in charge of Capt. W. H. Heuer, Corps of Engineers.—This work is for the defense of the important harbor of Key West.

During the past fiscal year operations were restricted to caring for the public property and buildings, and repairing such damages as were caused by the hurricane of October, 1876.

No appropriation was made for the fiscal year ending June 30, 1878.......
Appropriation asked for next fiscal year.................................. $75,000 00

Fort Jefferson, Garden Key, Tortugas, Florida, in charge of Maj. Jared A. Smith, Corps of Engineers, until December 16, 1876; since that date in charge of Capt. W. H. Heuer, Corps of Engineers.—The guns of this work perfectly command the admirable harbor lying in the heart of this group of keys.

During the past fiscal year the expenditure of money has been confined to the care of public property and buildings.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year.................................. $25,000 00

Fort Pickens, Pensacola Harbor, Florida, in charge of Capt. A. N. Damrell, Corps of Engineers.—This work, with Fort Barrancas and the proposed new batteries near the site of Fort McRee, constitute the defenses to the town and harbor of Pensacola, and to the navy-yard at Warrington.

During the past year, the modifications on bastion D were completed, and some repairs made to terre-plein, stairs, bermes, and water conductors, when work under special appropriation was suspended. Operations during the present fiscal year will be confined to ordinary repairs, and care and preservation of the public property.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year.................................. $75,000 00

Fort Barrancas and redoubt, Pensacola Harbor, Florida, in charge of Capt. A. N. Damrell, Corps of Engineers.—No changes have been made in this work during the last fiscal year, operations having been restricted to those necessary for the proper care and preservation of the property. No operations are proposed for next fiscal year.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Fort McRee, Pensacola Harbor, Florida, in charge of Capt. A. N. Damrell, Corps of Engineers.—The condition of this work is about the same as at the date of the last annual report.

If any appropriation is made for the fiscal year ending June 30, 1879, it is proposed to expend it in the prosecution of work on the batteries proposed by the Board of Engineers for Fortifications, June 6, 1874.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year to continue the battery $50,000 00

Fort Morgan, eastern entrance to Mobile Bay, Alabama, in charge of Capt. A. N. Damrell, Corps of Engineers.—This work, with Fort Gaines on the western side of the entrance, forms the outer line of defense to the harbor and city of Mobile.

The amount allotted this work from the appropriation for preservation and repair of fortifications was expended on the slopes, terre-plein, main drain, and minor repairs of the fort.

The sum of $27,000 having been allotted from the appropriation for contingencies of fortifications for the extension of the sea-wall to prevent further destruction of the site of the fort, preparations for the prosecution of this work were at once made, and in May, 1877, the construction of the coffer-dam, for 750 feet of wall, was commenced. All the main piles are driven, capping and stringers bolted on, and 450 feet of sheet-piling set in place.

It is contemplated to complete the construction of the sea-wall during the present working season, and make ordinary repairs to the fort, and take proper care of public property during the fiscal year.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $75,000 00

Fort Gaines, Dauphin Island, Mobile Bay, Alabama, in charge of Capt. A. N. Damrell, Corps of Engineers.—Operations during the year were confined to general repairs to fort-keeper's and ordnance sergeant's quarters, and to the construction of brush-apron and jetty, to prevent the further wasting of the beach, and consequent undermining of the office-building.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $50,000 00

Fort on Ship Island, coast of Mississippi, in charge of Capt. A. N. Damrell, Corps of Engineers.—This work affords shelter to light-draught vessels moving in Mississippi Sound.

During the past year such small repairs as were most pressingly needed were made upon the work, store-rooms, and quarters.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Fort Pike, Rigolets Pass, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—This work commands the passage by vessels drawing 7 feet or less, through the Rigolets into Lake Pontchartrain, and to the wharves on the lake front of New Orleans. Projects for its modification, in accordance with the approved system, were approved in 1870, and detailed estimates of the cost of the proposed modifications made.

During the past fiscal year operations have been confined to necessary repairs for the preservation of the work.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Fort Macomb, Chef Menteur Pass, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—This work commands the passage by vessels drawing 4½ feet or less, through the Bayou Chef Menteur, into Lake Pontchartrain, and the road along Gentilly Ridge, to the city of New Orleans.

During the past fiscal year operations have been limited to repairs necessary for the preservation of the work.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Tower Duprés, Lake Borgne, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—This old work is situated at the entrance of Bayou Duprés into Lake Borgne.

During the year work was confined to such slight repairs to the tower as were necessary for its preservation.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Battery Bienvenue, Lake Borgne, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—This battery is situated at the junction of two branches of the Bayou Bienvenue, about three miles from its mouth.

During the year operations were limited to the care and preservation of the work.

This work has no armament; the parade is flooded by high tides and storms; what remains of the buildings will stand, it is thought, for years without material injury, and the cost of caring for the work seems greater than warranted by its present value.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Tower at Proctorsville, Lake Borgne, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—No work was done during the past fiscal year beyond that required for care of the work.

The work is unfinished, unarmed, and of obsolete construction.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Fort Jackson, Mississippi River, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—This work, and Fort Saint Philip, nearly opposite, are situated on the Mississippi River, about 65 miles below New Orleans, and are the most important of those guarding the approaches to New Orleans.

Operations during the past fiscal year were confined to the care and preservation of the work.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year.................................. $25,000 00

Fort Saint Philip, Mississippi River, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—During the past fiscal year no work was performed beyond that necessary for the care and preservation of the work.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year.................................. $25,000 00

Fort Livingston, Barataria Bay, Louisiana, in charge of Capt. C. W. Howell, Corps of Engineers.—This barbette work is situated on the west-

ern end of Grand Terre Island, at the entrance to Barataria Bay. It guards the only approach to New Orleans by vessels drawing 7 feet or less, available on the west side of the Mississippi River. It also secures a safe anchorage and harbor of refuge for our light-draught coasters in time of war.

Operations during the past fiscal year were confined to the care and preservation of the work.

No appropriation was made for the fiscal year ending June 30, 1878.
No appropriation asked for next fiscal year.

Fort at Fort Point, entrance to San Francisco Harbor, California, in charge of Lieut. Col. C. S. Stewart, Corps of Engineers.—This is one of the principal works for the defense of the entrance to the harbor of San Francisco, through the Golden Gate, the approaches to this entrance, and the inner waters of this passage.

No operations have been carried on at this work during the past fiscal year, except for the proper care and preservation of the work and property. The barbette earthen batteries connected with the main work are much in the same condition they were at the date of the last annual report. To complete these batteries to receive their armament, it will require at least $100,000. There have been no changes of armament during the year.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year.................................. $100,000 00

Fort at Lime Point, San Francisco Harbor, California, in charge of Maj. George H. Mendell, Corps of Engineers.—This fort, with its detached earthen barbette works, at Point Cavallo, Lime Point Ridge, and Gravelly Beach, constitute the defenses of the entrance to the harbor of San Francisco on the northern shore of the Golden Gate.

No work has been done on these batteries during the past year. The property has been under the charge of fort-keepers. The condition of the works is good. In order to complete these batteries, it will be necessary to build 22 gun-platforms and 7 breast-height walls.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year.................................. $80,000 00

Fort on Alcatraz Island, San Francisco Harbor, California, in charge of Maj. George H. Mendell, Corps of Engineers.—This work occupies a valuable position for the defense of the entrance to and the inner waters of the harbor of San Francisco, covering the whole of a rocky island, the shores of which rise abruptly from the water to a height sufficient to secure it from surprise. The fortifications have, from their inception, consisted chiefly of open barbette batteries for the heaviest guns.

All the work accomplished during the past fiscal year was done by the prisoners, from whom 3,027 days' labor was secured. This labor was applied in great part to excavation of the parade at the southern end of the island, of which 5,368 cubic yards were taken out. Magazine P was covered with earth, its floor asphalted, and the gutters in the passage-way concreted. The prisoners were withdrawn in March. The works are in good condition. No changes have taken place in the armament during the year, nor in the number of platforms ready for service.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year.................................. $50,000 00

Batteries at Point San José, San Francisco Harbor, California, in charge of Lieut. Col. C. S. Stewart, Corps of Engineers.—These temporary

batteries are in an unserviceable condition. The timber platforms and revetments and timbers of the magazines are rotten and falling to pieces. No work was done during the past fiscal year, and none is contemplated during the present year, excepting repairs necessary for practice-firing.

Batteries on Angel Island, San Francisco Harbor, California, in charge of Lieut. Col. C. S. Stewart, Corps of Engineers.—These three temporary earth-works, constructed during the late war, are essentially unserviceable. The platforms are decayed, and most of the carriages have been condemned. It is not intended to commence the construction of batteries of a permanent character projected to replace them until more advanced points of the exterior line of defense are fortified.

Fort at San Diego, California, in charge of Lieut. Col. C. S. Stewart, Corps of Engineers.—This work is situated on Ballast Point, near the mouth of the bay and harbor of San Diego, and commands the channel of entrance thereto.

There having been no special appropriation for this work, it has during the fiscal year been cared for by a watchman. The property is in as good condition as can be expected under the circumstances. It is estimated that it will require at least $130,000 to complete the work.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $50,000 00

Defenses at the mouth of the Columbia River, Oregon, in charge of Maj. John M. Wilson, Corps of Engineers.—The defenses consist of Foot Stevens, Point Adams, Oregon, on the south side, and Fort Canby, Cape Hancock, Washington Territory, on the north side of the entrance to the river. These works are earthen barbette batteries, and constitute the only defenses of the mouth of the Columbia River.

Fort Canby.—The three batteries require extensive repairs; two of the service magazines are entirely in ruins, and the third needs repairs; the wooden revetments and platforms are rapidly decaying; the roads leading to the batteries should be repaired. No work has been done during the past fiscal year for want of funds.

Fort Stevens.—All the platforms, except that of the 15-inch gun, are badly decayed and should be renewed; the drainage of the ditch requires attention. During the past year the revetment of the interior slope has been renewed wherever necessary, the old ruined traverses removed, and minor repairs made to the work; the fort now presents a good appearance.

In order to preserve the site of this work, upon which the sea was rapidly encroaching, a revetment of stone and brush about one thousand feet long was constructed where the erosion was making the most progress; its success cannot be determined until the fall gales commence.

Surveys have been made of Sand Island, Clatsop Spit, and the Swash Channel, and charts prepared.

No appropriation was made for the fiscal year ending June 30, 1878.
Appropriation asked for next fiscal year $30,000 00

BOARDS OF ENGINEERS.

The Board of Engineers for Fortifications, stationed in New York City, consisting of Col. J. G. Barnard, Col. Z. B. Tower, and Lieut. Col. H. G. Wright, and, for the time being, the officer in charge of the defenses under consideration, has, during the past fiscal year, been chiefly en-

gaged upon project of Beverly Kennon for a counterpoise battery; upon question of practical benefits expected to be realized from the labors of the board appointed to test iron, steel, and other metals; upon question whether the erection of the proposed colossal statue of Liberty within main work on Bedloe's Island, New York Harbor, will seriously interfere with the defense of the position; upon design of Herr Krupp for a muzzle pivoting gun; upon Lieutenant Ruffner's translation of paper on "Armored Turrets;" upon question of modification or amendment to "Bill to provide for the more thorough investigation, by a board of engineer officers, of accidents on railroads."

During the year the board has also prepared plans for the modification of Fort Clinch, Fernandina Harbor, Florida, with estimates for same; has had under consideration the fortification of the entrance to Portland Harbor, Maine, by way of Hussey's Sound; designing and preparing plans of batteries for the occupation of Cow Island, the northeast portion of Hog Island, also the northwest portion of the same island to cover the anchorage between the island and the main shore. These plans are well advanced.

The board has also under investigation the modification of exterior batteries at Fort Washington, Maryland, plans of which are progressing well.

The study of the question of the application of casemate-shields to Fort Schuyler, with a view to the eventual introduction of the largest possible guns into these casemates, has occupied the attention of the board, as well as the study and investigation of the subject of redoubts or keeps for the defense of isolated batteries, of which so many have been designed, at positions too remote from forts to derive any protection from them.

The question of building a large storage magazine in Fort Delaware, and proposed methods of giving security to magazines already constructed, are still under consideration. The defense of San Francisco Harbor by torpedoes is also under study.

TORPEDO DEFENSE.

The report of the board upon the progress made in torpedo defense, in connection with which Maj. H. L. Abbot, in charge of the torpedo experiments, depot and school of instruction at Willets Point, is a member, is substantially as follows:

TORPEDO TRIALS.

The trials designed to develop the best system for the torpedo defense of the sea-coast of the United States have been continued at Willets Point during the past year, use being made as heretofore of the engineer troops, for their instruction, and to avoid the expense of hired labor. The following is a summary of the work done:

Submerged ring.—Sixty-nine shots have been fired in the submerged ring and the indications of the pressure-gauges carefully recorded. These investigations were directed to determining—

1. The effect of long storage upon dynamite supplied by the manufacturing companies. Samples received at different dates during the past five years were tried and found to possess identical strength with that newly made. Repeated freezing and thawing apparently had caused no deterioration.

2. The influence of variation in strength of case upon work utilized.

As might be foreseen, there is a striking difference in this respect between gunpowder and dynamite. With the former the time needed for complete combustion is sensible, and if the case gives way before the burning is complete, loss necessarily results. The latter detonates instantly, and consequently all work expended in rupturing the case is subtracted from that registered upon the gauges. A thin rubber bag developed the maximum indications, and a stout wooden envelope the minimum. The latter was reduced to what resembled saw-dust.

3. The effect of an air-chamber in the case, with dynamite. Within the usual limits of practice, and for a suitable head of water, no loss of power is indicated.

4. The comparative strength, as compared with dynamite, of wet disk and wet granulated gun-cotton, and of Vulcan powder. For subaqueous explosions the former is decidedly the stronger.

5. To ascertain if an instrumental correction is required for slight variations in the length of the hole leading to the head of the gauge-pin. None proved to be necessary within the limits of practice.

6. The effect of successive shots upon the same lead cylinders. Some interesting results, not necessary to discuss here, were obtained.

Torpedo target.—In continuation of former trials, a charge of 200 pounds of dynamite was exploded, by which the target was sent to the bottom much shattered in bolts and braces and badly cracked in some of the plates. The blow was not destructive, and repairs have been made in preparation for a final shot, which will be fired during the present summer.

Torpedo materiel.—The experiments to test, practically, the strength and endurance of the service patterns of torpedo materiel have been continued.

A cut-off box was left in position for six months, under a head of 80 feet of water, without developing any tendency to leakage around the insulated wires.

The new model spherical torpedo, 32 inches in diameter, proves to be quite uninjured by the explosion of 100 pounds of dynamite at a horizontal distance of 50 feet; the submergence being 9 feet in 21 feet of water.

For resisting the blows of passing vessels this model has shown satisfactory endurance; one being struck eleven times, five blows being by the largest class of sound steamers, before beginning to leak.

The circuit-regulator set as a closer is unaffected by the explosion of 100 pounds of dynamite at a horizontal distance of 50 feet; but as a breaker it is more sensitive. This, however, is a matter of no practical importance, as the disconnector is a perfect protection against accidental explosions in such cases.

Against long exposure to the corroding effects of sea-water and the influence of tidal currents and waves, the material seems to be well proportioned; the only part showing weakness after a continuous trial of three years in the channel at Willets Point being the wire mooring-rope, which it was necessary to replace in about eighteen months.

Experiments with the electric light have been continued, and are still in progress. They have included a laborious series of battery measurements to determine the best pattern of voltaic cell for use in service, should that generator of electricity be preferred.

The multiple cable laid between Willets Point and Fort Schuyler has remained in working order, although severely strained by an anchor in November last. The repeated injuries of this nature which the cable has received have caused a bad fault in one of the seven cores and

moderate leakage in two of the others, all of which it is proposed to repair during the summer.

Major Abbot is now engaged in working out the details of a new variety of self-acting contact torpedo, which promises to possess important advantages. Although the employment of this class of torpedo will be much restricted by the necessity of providing for the safe passage of our own vessels, it is desirable to decide upon an approved pattern for use in possible contingencies, and for this reason the subject has received attention.

Reduction of data.—A large collection of data has accumulated during the series of torpedo trials since the year 1869, which it is desirable to put in form for use. This work has necessarily been deferred partly because of the incomplete state of the investigations and partly because the more urgent demand for a torpedo manual has rendered it impossible for Major Abbot to give the subject the necessary attention.

During the past year, however, the Hell Gate current data have been analyzed sufficiently to justify the selection of suitable sizes of buoyant torpedoes to correspond with the tidal currents and depths observed in our different harbors.

The torpedo manual will consist of three parts, of which the first and second are chiefly in type, while much progress has been made on the third. It is hoped that the final reduction of data will be begun during the coming year.

RECOMMENDATIONS.

The present condition of our preparations for defending the sea-coast with torpedoes is briefly as follows: The several important harbors have been carefully studied, and for most of them detailed plans have been prepared. Casemates for the reception of the cables in a manner to render them secure against bombardment, and to safely operate the system, have been projected and several of them constructed. Considerable supplies of apparatus and of torpedo insulated cable are accumulated at the Willets Point depot ready for service. The needful data for increasing these supplies in a judicious and economical manner have been obtained. The board therefore recommends:

1. That special appropriations be asked for to prepare the necessary bomb-proof operating-rooms and cable-galleries for those forts not already provided with them.

2. That an appropriation of $100,000 be asked for to continue the purchase of torpedo materiel not easily to be obtained in haste, for the continuation of torpedo trials, and for the practical instruction of the engineer troops in the details of this service.

3. That the authorized number of these troops (now only 200) be increased to 520 men, and a provision inserted in the law requiring them to be thoroughly trained in the use of torpedoes for harbor defense. The number of engineer troops now authorized by law is 752, but the successive reductions of the Army have caused the limit of 200 men to be prescribed in existing orders. This number is entirely insufficient, and the board has again placed on record its opinion that though the system be perfect, and the supply of materiel ample, failure in time of war will be more than probable unless this vitally important matter receives attention in time of peace. Special and long-continued training is absolutely essential to efficiency in this new and exacting branch of warfare. The duties of the engineer troops in bridge-building and military mining on land, and the higher degree of intelligence required as a

condition of their enlistment, render them specially fitted for the work of torpedo service; and it is believed that if the matter were properly understood any needful provisions would be made by Congress as a measure of true economy and necessity.

The Board of Engineers for the Pacific coast during the past fiscal year has consisted of Lieut. Col. B. S. Alexander, Lieut. Col. C. S. Stewart, Lieut. Col. R. S. Williamson, and Maj. George H. Mendell, with First Lieut. John H. Weeden recorder, until his death, January 29, 1877, and First Lieut. A. H. Payson recorder from March 20, 1877, to date.

During the past year the board has acted and reported upon examination, projects, and estimates of cost for the improvement of the lower Willamette and Columbia rivers, Oregon; examination and report upon the roadsteads of California and Oregon, between San Francisco and the mouth of the Columbia River, with a view to establishing a breakwater and harbor of refuge on this coast; making plans and estimates of the cost of the same; consideration of the encroachments of the sea and of the Columbia River on the shore of Point Adams, Oregon, threatening the site of Fort Stevens; and consideration of the repairs of battery at Point San José, San Francisco Bay.

BATTALION OF ENGINEERS AND ENGINEER DEPOTS.

Battalion of Engineers, commanded by Maj. Henry L. Abbot, Corps of Engineers, headquarters Willets Point, eastern entrance to New York Harbor.

The strength of the Battalion of Engineers on June 30, 1877, was fourteen commissioned officers and two hundred enlisted men, the reduction to this standard being effected on the 15th of June by the summary discharge of eighteen men.

The companies are stationed and commanded as follows: At Willets Point, New York Harbor, Company A, Capt. Thomas H. Handbury; Company B, Capt. A. M. Miller; Company C, Capt. W. R. Livermore; Company D, (skeleton organization,) First Lieut. B. D. Greene. At West Point, N. Y., Company E, Captain O. H. Ernst, also instructor in practical engineering and *ex-officio* member of the academic board.

Detachments have served as follows: Department of Dakota, two sergeants and four privates; Department of the Missouri, two sergeants, one corporal, and two privates; at the Centennial Exhibition, one lieutenant, one corporal, and seven privates.

The battalion also furnished the guard during the final operations at the Hallet's Point (Hell Gate) explosion. Three officers were detached for temporary duty on the survey of the Union Pacific and Central Pacific Railways.

Recruiting has been discontinued, except in the case of re-enlistments and to fill vacancies in the company stationed at West Point.

The following table exhibits a synopsis of the recruiting service and of desertions from June 30, 1865, to June 30, 1877, a period of twelve years, beginning with the close of the war.

	Enlisted.	Re-enlisted.	Deserted and apprehended.	Deserted after enlistment. First three months.	Second three months.	Second six months.	Second year.	Third year.	Fourth year.	Fifth year.	Total.
During the third quarter of 1865-'71	610	46	36	114	108	73	64	14	0	0	373
During the fourth quarter of 1865-'71	552	67	24	90	66	29	26	4	0	0	215
During the first quarter of 1866-'72	529	76	57	57	81	55	28	2	0	0	223
During the second quarter of 1866-'72	406	23	24	82	99	80	31	9	0	0	301
During the third quarter of 1872	16	0	4	12	14	9	9	5	1	0	50
During the fourth quarter of 1872	51	1	1	13	0	4	0	3	0	0	20
During the first quarter of 1873	45	1	1	9	7	4	3	1	0	0	24
During the second quarter of 1873	30	0	4	18	18	11	2	0	1	0	50
During the third quarter of 1873	28	1	3	7	8	2	4	2	0	0	23
During the fourth quarter of 1873	44	0	23	6	3	0	0	1	0	0	10
During the first quarter of 1874	6	2	19	0	7	4	0	0	1	0	12
During the second quarter of 1874	18	6	2	0	6	2	3	1	0	0	12
During the third quarter of 1874	5	5	0	2	0	1	2	1	1	0	7
During the fourth quarter of 1874	2	10	3	0	1	0	0	1	0	0	2
During the first quarter of 1875	4	13	0	0	0	0	1	2	0	0	3
During the second quarter of 1875	3	9	1	0	0	1	3	0	0	0	4
During the third quarter of 1875	2	13	1	0	1	0	0	0	0	0	1
During the fourth quarter of 1875	5	14	1	0	1	0	1	0	0	1	3
During the first quarter of 1876	2	3	0	1	0	0	3	1	0	0	5
During the second quarter of 1876	4	5	1	1	0	2	0	1	0	0	4
During the third quarter of 1876	3	14	2	0	0	0	0	1	1	0	2
During the fourth quarter of 1876	1	14	1	0	0	0	1	0	0	0	1
During the first quarter of 1877	0	18	2	1	0	0	2	0	0	0	3
During the second quarter of 1877	3	2	1	0	0	0	0	1	0	0	1
Total during third quarter of 1865 to 1876	664	79	46	135	131	85	79	23	3	0	456
Total during fourth quarter of 1865 to 1876	665	106	53	109	71	33	28	9	0	1	251
Total during first quarter of 1866 to 1877	586	113	79	68	95	63	37	6	1	0	270
Total during second quarter of 1866 to 1877	464	45	33	101	123	96	39	12	1	0	372
Grand total for twelve years	2,369	343	211	413	420	277	183	50	5	1	1,349

At Willets Point, in addition to the ordinary military duties of the garrison, the troops have guarded, received, and issued the property pertaining to the engineer depot, remodeled a portion of the bridge-equipage, guarded and done necessary work upon the permanent fortification, and constructed and remodeled certain post buildings.

At West Point, Company E, in addition to ordinary post duties, has aided in the practical instruction of the cadets in pontoneering, signaling, telegraphy, and field fortification.

At both Willets Point and West Point, all needed facilities are available for the instruction of the troops in the military duties of their arm of service, except that at West Point no torpedo drills are practicable.

The commissioned officers of the battalion at Willets Point have also special advantages in the way of preparation for duty on the public works usually assigned to the corps.

The progress in field fortification, pontoneering, and infantry tactics has been all that is practicable with the reduced number of the battalion and the pressure of other duties.

A modified course of instruction in photography for officers and non-commissioned officers has been commenced. The studio has been materially improved, and the facilities for obtaining a thoroughly practical understanding of the different processes and manipulations involved in photographic operations greatly increased. The beneficial results of these changes are already conspicuous in the increased interest taken in the work by the officers and the very creditable character of the work recently produced.

Special importance has been given to the copying of maps for military purposes, and during the ensuing year it is intended that the photo-lithographing of maps shall be studied and experimented with.

In submarine mining the general system of instructions has been continued with satisfactory results.

As heretofore, much work has been done by the men in carrying out the torpedo-trials now being made.

The following recommendation made in my last annual report is renewed and respectfully urged upon the attention of the Secretary of War:

"In our service, as in that of Great Britain and other nations, the duty of devising and perfecting a system of torpedo-defense, to be used in combination with the forts, and of practically applying it in case of war, has been assigned to the engineer troops. The legal organization of the battalion (752 enlisted men) is sufficient to warrant a reasonable expectation that, with the needful material in store, this highly important duty will be satisfactorily performed. Under existing orders, issued at the recent reduction of the Army, the force authorized to be kept in service is fixed at 200 men; a number quite insufficient to afford any proper grounds for believing that even our more important sea-ports could be properly protected by torpedoes in time to prevent their destruction. Every effort is now making to thoroughly prepare the men for these duties, which involve long training and higher intelligence than it is common to find in the ranks. Individual records are kept, showing the qualifications of each man, as determined by his instructors from his regular drills and exercises. But still the fact remains that the force is too small to perform the responsible duties assigned to it, and I therefore feel it my duty to urge that the organization may be recruited to 520 men, the number judged to be the minimum consistent with a reasonable state of preparation for unexpected hostilities. This number is but little more than two-thirds of the maximum fixed by law, and no increase in the legal organization is therefore needed."

In this connection it should be borne in mind that the Battalion of Engineers, while ordinarily engaged on its separate and special duties, is, in time of emergency, such as occurred during the late riots, available as infantry of the line. When so called upon, its discipline and general efficiency has merited and received the highest commendation.

Engineer post and depot at Willets Point, New York Harbor, commanded by Maj. Henry L. Abbot, Corps of Engineers.—Willets Point is the principal engineer-depot of the Army, where are stored the field-trains, the tools, the torpedo material, and the surveying and astronomical instruments used by the corps. The property is cared for, guarded, and issued by the engineer troops.

The post has become a useful school of application for officers and men, where the duties of the torpedo service, military-bridge making, field-fortification, military reconnaissance, field-photography, &c., are taught. The officers are also furnished with the necessary facilities for perfecting themselves in the use of the instruments employed upon every variety of work assigned to the corps.

The buildings of the establishment are essentially completed, and the only appropriations requested are $1,000 for the purchase of engineer materials to be used for the instruction of the troops, and $4,000 for contingent expenses, such as remodeling ponton-trains, repairing instruments, purchasing fuel, forage, stationery, chemicals, extra-duty pay for soldiers engaged in special skilled labor, such as wheelwright-work, printing and binding engineer documents, photographing and lithographing plans, &c., and for needful repairs of buildings.

Estimate of funds required for Battalion of Engineers and engineer depot at Willets Point, New York, for the fiscal year ending June 30, 1879.

For purchase of engineer materials to continue the present course of instruction of the battalion in field-engineering	$1,000 00
For the incidental expenses of the depot, such as remodeling ponton-trains, repairing instruments, purchasing fuel, forage, stationery, chemicals, extra-duty pay for soldiers engaged in special skilled labor, such as wheelwright-work, printing, binding, photographing and lithographing, engineer documents, &c	4,000 00
Total	5,000 00

RIVER AND HARBOR IMPROVEMENT.

The funds with which the works for the improvement of navigation in rivers and harbors have been prosecuted during the past fiscal year have been derived from the balances of the appropriations of March 3, 1875, and of previous dates, together with such portions of the appropriation of August 14, 1876, as were from time to time made available.

In the last annual report from this office a tabulated statement was made of the amounts allotted to the works of improvement from the several specific appropriations contained in the act of August 14, 1876.

Subsequent to that report several allotments were made at different dates until April 28, 1877, when, by authority of the Secretary of War, all the remaining balances of unallotted appropriations of that act, amounting to $1,124,100, were made available, and active operations were resumed at all the works thus provided for, and satisfactory progress has been made during the fiscal year.

A brief statement is given below setting forth the condition of each improvement, the extent of work performed during the year, amount of money expended, and an estimate of the probable cost of completion, together with an estimate of the amount that can be profitably expended during the year ending June 30, 1879. The reports of the officers in charge of the various improvements will be found in the appendix, and to these reports special reference should be made whenever detailed information is desired concerning the progress and condition of each individual work.

With the view to a compliance with the third section of the river and harbor act of August 14, 1876, which requires a report to Congress of all the instances in which structures built by the United States in aid of commerce or navigation are used, occupied, or injured by corporations or individuals, the extent of such injury and the facts touching the same, and also what legislation is necessary to protect public works against trespass or injury thereto, officers of engineers and agents in charge of public works were instructed to report all such instances within their knowledge, and their views as to the legislation which would best prevent the evils in question. Their replies were embodied in a letter from this office to the Secretary of War, of January 13, 1877, including the form of an act intended to cover all cases likely to arise, and was sent from the War Department to the House of Representatives January 17, 1877. It does not appear that this communication was printed or that any action was taken upon it by that body. It will be found in Appendix W 3.

ATLANTIC COAST.

IMPROVEMENT OF RIVERS AND HARBORS IN THE STATES OF MAINE, NEW HAMPSHIRE, AND MASSACHUSETTS.

Officer in charge, Lieut. Col. George Thom, Corps of Engineers.

1. *Saint Croix River, above the "Ledge," Maine.*—This river throughout its whole extent forms a part of the international boundary between Maine and New Brunswick. A survey of it was made in 1873, under the direction of Lieut. Col. Thom, from the "Ledge" up to the toll-bridge between Calais and Saint Stephens, the head of navigation, a distance of about 5 miles, with a view to the improvement of this portion of the river. The channel of the river was found to be much obstructed by shoals, caused by the deposit of slabs, edgings, and saw-dust thrown into the river from the saw-mills above, then estimated at not less than 1,000,000 cubic yards. To open a channel of practicable width and depth through these shoals (say 200 feet in width and 9 feet in depth at mean low-water, and 29 feet at mean high-water) it is estimated would require the excavation of 235,000 cubic yards of "mill-waste," at a probable cost of $150,000.

The following appropriations have been made by Congress for the improvement of this river, to wit:

By act approved March 2, 1867	$15,000 00
By act approved March 3, 1873	10,000 00
By act approved June 23, 1874	10,000 00
Total	35,000 00

The act of March 2, 1867, contained the proviso that—

The province of New Brunswick contribute and pay to the proper disbursing officer a like sum for said purpose, said payment being made on condition that in no event shall the province of New Brunswick be called upon for more than half the sum actually expended for said purpose.

In 1873, the Dominion of Canada appropriated the sum of $25,000 for the improvement of this river; but in consideration of the fact that the obstructions to its navigation have been caused by the deposit of the "waste" from the saw-mills above, and that no law is in force for preventing the continuation of this practice, the department of public works of the Dominion of Canada declined to authorize the expenditure of the appropriation until satisfied that this practice is permanently discontinued.

July 1, 1876, amount available	$34,185 58
July 1, 1877, amount expended during fiscal year	185 58
July 1, 1877, amount available	34,000 00
Amount (estimated) required for completion of existing project	40,000 00

(See Appendix A 1.)

2. *Machias River, Maine.*—The following appropriations have been made by Congress for the improvement of this river, viz:

By act approved March 3, 1873	$12,000 00
By act approved June 23, 1874	10,000 00
By act approved March 3, 1875	10,000 00
Total	32,000 00

All the work projected for the improvement of this river was completed in November, 1876, and all the appropriations made therefor, as above, have been expended. These improvements consist of the re-

moval of a very large and dangerous ledge (known as Middle Rock) which seriously obstructed the channel of the wharves at Machias, and in the excavation of the several shoals of slabs, edgings, &c., below, so as to obtain a channel 6 feet in depth at mean low-water (or 19.3 feet at ordinary high-water) for a width of not less than 100 feet from deep-water near East Machias bridge up to the wharves at Machias, a distance of 3 miles. This work has required 1,350 cubic yards of rock-excavation and 33,000 cubic yards of dredging.

As the shoals in this river have been caused chiefly by the slabs, edgings, and sawdust from the saw-mills at and above Machias Falls, they will, of course, continue to form, so long as the mills shall be permitted, as at present, to throw their "waste" into the river; so that the improvements now made will probably be but temporary.

July 1, 1876, amount available	$9,350 50
July 1, 1877, amount expended during fiscal year	9,350 50

(See Appendix A 2.)

3. *Penobscot River, Maine.*—The work originally projected for the improvement of this river consisted—

A. In the enlargement and straightening of its channel through the several bars and shoals at and near Bangor, so as to have a width of not less than 200 feet, and a depth not less than 11 feet at low tide (or 24 feet at high tide) in the lowest stages of the river, giving about 14 feet at low tide in its ordinary stages.

B. In breaking up and removing all the sunken rocks in the harbor of Bangor down to the level of the general bed of the river near them, so as to have not less than 7 feet of water over them in the lowest stages of the river, except "Green's Pier Ledge," so called, which now has about 5 feet of water over it in those stages, or 8 feet at low tide in its ordinary stages.

At the beginning of the fiscal year (July 1, 1876,) the projected improvement of all the bars and shoals had been completed with the exception of the channel through the Middle Ground at Bangor; and all the sunken rocks had been broken up and removed to the extent projected, with the exception of Green's Pier Ledge, and some others discovered in October, 1875, in and near the Middle Ground Channel; contracts had also been made for completing all the dredging on the Middle Ground, and for completing the removal of Green's Pier and Green's Pier Ledge, under which considerable progress had then been made.

During the past year the removal of Green's Pier and the ledge has been completed, and a contract has been made for breaking up and removing a portion of the sunken ledge in the Middle Ground Channel, the same to be completed before the close of the present season. The excavation of the Middle Ground Channel by dredging is now about four-fifths completed, with a probability of its being entirely so before the close of the present season.

Under the appropriation of $10,000 made by act of March 3, 1875, to be expended for the improvement of the river at and near Bucksport Narrows, (18 miles below Bangor,) a survey was made to ascertain the object of the appropriation, which resulted in a project for the improvement of its navigation by the removal of the Middle Ground in front of the wharves at Bucksport to a depth of 12 feet at mean low-water, or 22.3 feet at ordinary high-water. A contract was made for this work at 12½ cents per cubic yard, and it was completed on the 21st of October, 1875, by 61,910 cubic yards of dredging.

Under the appropriation of $4,000 made by act of August 14, 1876,

for the further improvement of Bucksport Harbor, a contract has been made for completing the dredging on the Middle Ground during the present season, at 30 cents per cubic yard, so that no further appropriation will be required for improving the river at Bucksport.

For completing the removal of the sunken ledges in and near the Middle Ground Channel at Bangor, as projected, the additional sum of $6,000 will be required.

The officer in charge of this work states that the throwing of sawdust into this river is still continued to a very great extent, and to the serious detriment of its navigation. In view of this, and of the fact that several other navigable rivers in his district, now being improved by the United States Government, are also being injured by the throwing in of slabs, edgings, and sawdust, by building of piers and bridge-draws in improper places, and otherwise, he suggests the passage of some general law for the protection and preservation of all navigable waters under the control of the United States Government, for the improvement of which Congress has already or may hereafter make appropriations.

July 1, 1876, amount available	$45,044 28	
Amount appropriated by act approved August 14, 1876	10,000 00	
		$55,044 28
July 1, 1877, amount expended during fiscal year	31,834 98	
July 1, 1877, outstanding liabilities	925 00	
		32,759 98
July 1, 1877, amount available		22,284 30
Amount (estimated) required for completion of existing project		6,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		6 000 00

(See Appendix A 3.)

4. *Belfast Harbor, Maine.*—A survey of this harbor was made in July and August, 1875, in compliance with the river and harbor act of March 3, 1875, by which it was ascertained that to so improve it as to afford a safe anchorage for shipping in all storms and have a suitable depth for the several steamers and other vessels that touch and lie there, in all stages of the tide, would require a breakwater and other works, the cost of which, as estimated by the engineer in charge of same, is $347,000.

The small amount (viz, $5,000) appropriated for this harbor by the river and harbor act of August 14, 1876, it has been deemed advisable to apply to the partial removal of the sunken ledge abreast Lane's wharf, for which a contract has been made, the work to be completed the present season. For completing the removal of this ledge and the shoals below to the projected depth will require an additional appropriation of $30,000, which can be profitably expended during the next fiscal year.

Amount appropriated by act approved August 14, 1876	$5,000 00
July 1, 1877, amount expended during fiscal year	9 00
July 1, 1877, amount available	4,991 00
Amount (estimated) required for completion of existing project	342,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	30,000 00

(See Appendix A 4.)

5. *Kennebec River, Maine.*—All the work projected for the improvement of this river has been completed, with the exception of the removal of Dry Rock, situated in the Narrows, about 1½ miles below Richmond. From Richmond up to Gardiner, a distance of 11 miles, the channel has

been made safe and navigable for a width of not less than 100 feet and for a depth of 10 feet at low tide (or 15½ feet at high tide) in its lowest summer stages; and from Gardiner to Augusta, a distance of 7 miles more, it has also been improved for a width of not less than 100 feet, so as to have not less than 6½ feet at low tide (or 11½ feet at high tide) in the lowest summer stages of the river.

Under a contract made May 6, 1875, for the removal of Dry Rock to a depth of 12 feet at mean low-water, operations have been carried on during the past fiscal year resulting in the removal to date of about 1,230 cubic yards of the rock. This work will probably be completed before the close of the present season, the funds available being sufficient for the purpose.

July 1, 1876, amount available		$27,815 33
July 1, 1877, amount expended during fiscal year	$11,125 77	
July 1, 1877, outstanding liabilities	7,200 00	
		18,325 77
July 1, 1877, amount available		9,489 56

(See Appendix A 5.)

6. *Portland Harbor, Maine.*—All the work projected for the improvement of this harbor has been completed, with the exception of the dredging in front of the harbor-commissioner's line above Merrill's wharf; but this work will be done only on condition that the several wharves above Merrill's wharf will be removed, so far as they extend beyond the harbor-line. The funds now available are sufficient for this purpose.

During the past fiscal year an accurate triangulation and survey, much needed, has been made of the wharves and harbor-lines; also a survey of the harbor in front of them, to ascertain what, if any, changes have taken place since it was dredged two years ago.

July 1, 1876, amount available	$44,568 98
July 1, 1877, amount expended during fiscal year	1,638 88
July 1, 1877, amount available	42,930 10

(See Appendix A 6.)

7. *Richmond's Island, Maine.*—The improvement projected for this place consists in making a harbor of refuge by means of a rubble-stone breakwater, to connect the island with main-land. The length of the proposed breakwater is about 2,000 feet, with an average thickness of 25 to 30 feet, and a height of 4 feet above ordinary high-water. During the past fiscal year work has been suspended for want of funds. To complete it in accordance with the original estimate, 10,000 tons more of stone will be needed, for which an appropriation of $15,000 will be required.

Amount (estimated) required for completion of existing project	$15,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	15,000 00

(See Appendix A 7.)

8. *Kennebunk River, Maine.*—The work hitherto done for the improvement of this river consists in the extension and repair of the two stone piers at its mouth, and the repair of the United States Government wharf, a short distance above its mouth.

For the entire completion of all the improvements necessary for this river, there remains only the deepening of the channel at the Wading Place and at Mitchell's Point, the estimated cost of which is $5,000, for which an appropriation was made by the river and harbor act, approved August 14, 1876. A contract has been made for completing this

work before the close of the present season. No further appropriation will therefore be required.

Amount appropriated by act approved August 14, 1876	$5,000 00
July 1, 1877, amount expended during fiscal year	8 00
July 1, 1877, amount available	4,992 00

(See Appendix A 8.)

9. *Cocheco River, New Hampshire.*—The improvement projected for this river consists in making a channel not less than 40 feet in width and 4 feet in depth at mean low-water (or 10.8 feet at mean high-water) from the Lower Narrows up to the Packet Landing.

The several appropriations made from March 3, 1871, to March 3, 1875, for this river have been applied to the following improvements, viz:

A. The excavation and removal of about 400 cubic yards of ledge at the Lower Narrows, and of numerous sunken rocks which obstructed the channel between the Lower and Upper Narrows, (including Watson's Rocks,) as well as some rocks below the Lower Narrows.

B. Opening a channel through the ledge at the Upper Narrows for a length of 430 feet and for a width of 40 feet and a depth of 4 feet at mean low-water.

C. Opening a channel through the ledge in front of Collins's wharf (above the Upper Narrows) for a length of 260 feet and for a width of 40 feet and a depth of 4 feet at mean low-water.

D. Excavating (by dredging) a channel 40 feet wide and 4 feet deep at mean low-water from Gulf Shoal up to Packet Landing, a distance of about half a mile.

The work done during the past fiscal year has been applied to the removal of sunken bowlders and ledges in and near the Lower Narrows, and at Trickey's Shoal and Clement Point Shoal. A contract has also been made for completing all the projected *dredging*.

The work that now remains to be done for completing the improvement of this river as now projected consists in the completion of the channel by *dredging* near Packet Landing, and, where necessary, at the shoals below, for which contracts have been made, the removal of sunken ledges and bowlders still necessary at and near the Lower Narrows and at Dover Point, and in excavating a channel through the ledge at Gulf Shoal, to effect which will, as estimated, require an additional appropriation of $11,000.

July 1, 1876, amount available	$2,881 56	
Amount appropriated by act approved August 14, 1876	14,000 00	
		$16,881 56
July 1, 1877, amount expended during fiscal year	5,046 26	
July 1, 1877, outstanding liabilities	607 22	
		5,653 48
July 1, 1877, amount available		11,228 08
Amount (estimated) required for completion of existing project		11,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		11,000 00

(See Appendix A 9.)

10. *Merrimac River, Massachusetts.*—All the work projected for improving the falls of this river above Haverhill, Mass., has been completed to the extent now deemed necessary. Newburyport Harbor, at the mouth of the river, has also been improved by the removal of South Gangeway Rock and of a wrecked schooner; and some progress has been made in the removal of North Gangeway Rock.

Between Newburyport and Haverhill the river has been improved by deepening the shoals and the removal of numerous bowlders which obstructed the channel above and below Rock's Bridge, including Petty Rock below and Little Currier Rock above the bridge. This work has all been completed except the removal of numerous sunken bowlders from the channel near Silby's Island, for which the funds now available are sufficient.

For completing all the work now projected for the improvement of Newburyport Harbor the additional sum of $25,000 will be required.

July 1, 1876, amount available	$10,460 54
July 1, 1877, amount expended during fiscal year	9,209 44
July 1, 1877, amount available	1,251 10
Amount (estimated) required for completion of existing project	25,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	25,000 00

(See Appendix A 10.)

11. *Salem Harbor, Massachusetts.*—The work projected for the improvement of this harbor consisted in the excavation, by dredging, of a channel 1,730 feet long and 300 feet wide to a depth of 8 feet at mean low-water (or 17.3 feet at mean high-water) from deep water to the entrance of South River; and for the building of a sea-wall and breakwater for the protection and preservation of Long Point.

Under the appropriation of March 3, 1873, this channel was opened for a width of about 160 feet, and under that of June 23, 1874, it was completed to the projected width of 300 feet.

For reasons stated by the engineer officer in charge of this harbor, the sea-wall and breakwater projected for the protection and preservation of Long Point are no longer deemed necessary, so that no further appropriation is now asked for the improvement of this harbor.

(See Appendix A 11.)

12. *Boston Harbor, Massachusetts.*—The following is a statement of the present condition of the several works completed, projected, and in progress for the improvement of this harbor, and the progress made upon them during the past fiscal year, viz:

A. *Sea-wall on Point Allerton.*—This wall was completed in May, 1874, together with a riprap apron-work for the protection of its foundation. Its total length is 1,202 feet. It is now in excellent condition in every respect, and fully answers the purpose intended.

B. *Sea-wall on Great Brewster Island.*—This wall is 2,840 feet in length, and was built for the protection of the north and south heads of that island, having been completed in 1870. It is in good condition and requires but few repairs.

C. *Sea-walls on Lovell's Island.*—The two sea-walls on this island were built by the United States Government, one in 1843 for the protection of its north head, and the other in 1867–'68 for the protection of its southeast bluff, for a length of about 800 feet. For the protection of the shore-line next south of the north-head wall, and next south of the southeastern wall, apron-work and jetties of rubble-stone were added in 1873. The wall on the southeast bluff has been much damaged by recent storms, and it is recommended that its height be increased 4 feet by adding two more courses, and that it be otherwise repaired, at a probable cost of $15,000. The other wall and apron-work are now in good condition, requiring no repairs, and fully answer the purposes intended.

D. *Sea-wall on Gallop's Island.*—This wall was commenced in 1868 and completed in September, 1871. It is 1,785½ feet in length, and has its foundation protected for nearly its whole extent by a riprap apron-work and stone jetties, which were added in 1873–'74. This work is in good condition and fully answers, in every respect, the purpose for which it was intended.

E. *Sea-wall on the north head of Long Island.*—This wall was commenced in 1870 and completed in the latter part of July, 1874, to a total length of 2,081¾ feet. For the protection of its concrete foundation, a riprap apron, with jetties, has been built on those parts where most exposed to injury by storms and currents, having been completed early in August, 1874. This work is in good condition, requiring no repairs, and fully answers the purpose intended.

F. *Sea-walls on Deer Island.*—The three sea-walls on this island were built about thirty-five years ago for the protection and preservation of the north, middle, and south heads, and were, respectively, 1,740, 840, and 380 feet in length. The injury which these walls had sustained from the violence of the storms was such as to necessitate the rebuilding of them to a great extent. This was commenced in 1865 and completed in 1869.

G. *Straightening, widening, and deepening the main ship-channel at the west end of Great Brewster spit.*—This work consisted in the removal, by dredging, of the southern portion of this spit, so as to give to the channel a width of 600 feet for a depth of 23 feet at mean low-water. Under a contract made in September, 1874, the dredging, which was commenced in October, 1874, was completed in August, 1875. During these operations a ledge was laid bare, of which 95½ cubic yards have since been broken up and removed to the required depth of 23 feet at mean low-water.

H. *Straightening, widening, and deepening the main ship-channel at the southeast and southwest points of Lovell's Island.*—This improvement consists in widening the channel so as to have a width of 600 feet for a depth of 23 feet at mean low-water.

Under the appropriation of June 23, 1874, a contract was made in September, 1874, for the dredging at the southeast point of this island. Work under this contract was commenced in October, 1874, and was completed in September, 1875.

For completing the improvement at and near the southwest point of this island about 40,000 cubic yards of dredging will be required, for which a contract has been made, the same to be completed during the present season.

I. *Straightening, widening, and deepening the main ship-channel at the upper middle bar.*—The improvement projected for this bar consists in excavating a channel for about 4,000 feet in length to a width of 600 feet and for a depth of 23 feet at mean low-water, the mean rise and fall of the tide being 10 feet. Dredging operations were commenced on the bar in 1870, and were continued, with intervals of suspension for want of funds, up to the 16th of November, 1876, when they were finally completed by a total of 266,794 cubic yards of dredging, of which amount 64,136 cubic yards have been done during the past fiscal year. In these dredging operations a sunken ledge was uncovered, containing about 80 cubic yards above grade. A contract has recently been made for its removal to grade, to be completed on or before the 1st of July, 1878.

J. *Removal of Nash's Rock, (Shoal.)*—This shoal lies in the entrance to Boston Harbor, about one-third of the way over from Brewster's Spit to Point Allerton. By a survey made in 1873, under the direction of

the engineer officer now in charge, it was ascertained that this shoal (previously known as Nash's Rock) is covered with bowlders, shingle, gravel, &c., and has an area of about 640 superficial yards with less than 21 feet of water over it at mean low-water, and an area of about 9 acres with less than 23 feet of water over it. The improvement here projected consists in its removal to a depth of 21 feet at mean low-water, which under a contract made May 19, 1875, was about half completed in September, 1876. Arrangements have been made for its entire completion during the present season.

K. *Removal of Kelly's Rock.*—This rock lies in the main ship-channel, distant about 700 yards, in a direction southeast by south from Bug light, (at "the Narrows,") and in the line of entrance buoy No. 1 and Bug light, and has always been a very dangerous obstruction to navigation.

In 1869 work was commenced upon the removal of this ledge to the depth of 23 feet at mean low-water, and was continued up to the end of 1870, leaving, as shown by surveys since made, a large area not having the required depth.

Under the appropriation of March 3, 1875, a contract was made May 14, 1875, for completing the removal of this rock. Work was commenced under this contract in the latter part of May, and was satisfactorily completed in September, 1875. During these operations of 1875 new ledges were discovered in the vicinity of Kelly's Rock, above and below it, having on the shoalest part a depth of 20 to 21 feet at mean low-water. To reduce them to the projected depth of 23 feet at mean low-water will require 189 cubic yards of excavation, for which a contract has recently been made, at $50 per cubic yard; the work to be completed on or before the 1st of July, 1878. Operations have been commenced under this contract.

L. *Removal of Tower Rock.*—This rock was situated in the main ship-channel at "the Narrows," about 100 yards to the southwest of Great Brewster Spit light. It was blasted out and removed in 1867 to the projected depth of 23 feet at mean low-water.

M. *Removal of Corwin Rock.*—This rock was situated in the main ship-channel at "the Narrows," about 200 yards to the southwest of Great Brewster Spit light. It was blasted out and removed in the years 1868 and 1869 to the projected depth of 23 feet at mean low-water.

N. *Removal of sunken ledge between George's Island and Great Brewster Spit.*—This ledge was discovered in September, 1872, in a resurvey of "the Narrows," made under the direction of the engineer officer now in charge. It was situated near the middle of the main ship-channel, distant about 317 yards, in a direction west by south from Bug light. It had but 18.9 feet of water over it at mean low-water, and was consequently a dangerous obstruction to navigation for the European steamers and other large vessels.

Under a contract made August 31, 1874, the removal of this ledge was completed in September, 1874, to the projected depth of 23 feet at mean low-water.

O. *Removal of Barrel Rock in Broad Sound.*—This was a bowlder, lying about one mile north of west from Green Island and near the sailing line of the Portland and other Maine steamers. It had only 4 feet of water over it at low tide, and in thick weather was a dangerous obstacle to navigation. It was removed in 1869.

P. *Removal of State and Palmyra Rocks.*—By a survey made in 1873, under the direction of the engineer officer now in charge, it was ascertained that these dangerous rocks, the position and character of which had previously been but little known, consisted of bowlders and ledges,

lying on the southern spurs of the "Lower Middle," which ocean-steamers and other large vessels had occasionally struck.

Under a contract made August 31, 1874, for the removal of these sunken rocks, work was commenced upon them in September, 1874, and on the 15th of June, 1875, their removal was completed.

Q. *Removal of wreck of schooner Delos.*—This vessel was sunk in 1872 in Nantasket Roads, about 100 yards from Fort Warren wharf, in about 22 feet of water at mean low-water, and was broken up and removed in May and June, 1873.

R. *Improvement of Hingham Harbor, Massachusetts.*—In the appropriation for Boston Harbor, made by act of March 3, 1875, provision was made for the improvement of Hingham Harbor, Massachusetts, to an extent not exceeding in cost $10,000.

The project for its improvement consisted in widening and deepening the main channel so as to have a width of not less than 100 feet and a depth of 8 feet at mean low-water (or about 6 feet at low-water in spring-tides) up to the wharves of Hingham, requiring 25,160 cubic yards of dredging and 80 cubic yards of ledge-excavation. This work has been completed.

From the report of the engineer officer in charge, it is seen that nearly all the works hitherto projected for the improvement of Boston Harbor have been completed, and the following only remain to be completed, viz:

1. About 40,000 cubic yards of dredging at and near the southwest point of Lovell's Island, in order to obtain the contemplated width and depth of channel, for which a contract has been made.
2. The removal of about 189 cubic yards of sunken ledges, discovered in 1875, in the vicinity of Kelly's Rock, and about 80 cubic yards of ledge at the Upper Middle, for which contracts have been made.
3. Completing the removal of Nash's Rock, (Shoal,) arrangements having been made for doing it the present season.
4. The removal of Man-of-War Shoal, in the upper harbor, requiring about 65,000 cubic yards of dredging, for which no funds are available.
5. Raising and repairing the southeastern sea-wall on Lovell's Island, for which no funds are now available.

July 1, 1876, amount available	$80,455 29	
Amount appropriated by act approved August 14, 1876	50,000 00	
		$130,455 29
July 1, 1877, amount expended during fiscal year	87,917 46	
July 1, 1877, outstanding liabilities	246 12	
		88,163 58
July 1, 1877, amount available		42,291 71
Amount (estimated) required for completion of existing project		55,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		55,000 00

(See Appendix A 12.)

13. *Plymouth Harbor, Massachusetts.*—The several appropriations heretofore made for this harbor have been applied to the construction of bulkheads, jetties, and groins for the preservation and strengthening of Long Beach, upon which the harbor depends for its existence. During the past year these works have been repaired and strengthened where most necessary, being now in a very good and effective condition. Repairs will, however, be required hereafter upon these works from year to year as heretofore, for which Congress will continue to be called upon for suitable appropriations.

By act of March 3, 1875, the sum of $10,000 was appropriated for

this harbor, and has been applied in part to improving the harbor itself. The project adopted consists in opening, by dredging, a channel leading from the Middle Ground up to the wharves of Plymouth, to a depth of 6 feet at mean low-water, or 16 feet at mean high-water, and for a towing width of 100 feet.

Under a contract made May 13, 1875, dredging operations were commenced in April and finished in June, 1876, resulting in 34,985 cubic yards in completion of the contract, by which the projected channel was opened for a width of 50 feet and to the depth required. For completing this channel as now recommended by the engineer officer in charge, and for the annual repairs of the works built for the preservation and protection of Long Beach, an additional appropriation of $30,000 will be required.

July 1, 1876, amount available	$327 42
July 1, 1877, amount expended during fiscal year	233 50
July 1, 1877, amount available	93 92
Amount (estimated) required for completion of existing project	30,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	30,000 00

(See Appendix A 13.)

14. *Provincetown Harbor, Massachusetts.*—The several appropriations heretofore made for the preservation and improvement of this harbor have been applied to the construction of the following works, viz:

A. Bulkheads and jetties of various descriptions have been built from time to time along Beach Point, for its preservation and protection, both by the United States Government and by the local authorities.

B. A dike was built in 1868 and 1869 by the State of Massachusetts, across the outlet of East Harbor Creek.

C. A dike was built in 1868 and 1869 by the United States Government across East Harbor Creek, at the Wading Place, near High Head, about 2 miles above the outlet of the creek.

D. Wooden bulkheads and jetties have been built at different times for the protection and preservation of the beach on Long Point.

E. A stone bulkhead has been nearly completed for the protection and preservation of the outer end of Long Point, the light-house and Three-gun Battery.

F. A dike (272 feet in length) was built in 1871–'72 across the head of Lancey's Harbor, near Abel Hill.

G. Beach-grass planted on Beach Point, Long Point, Abel Hill, Cove Section, and Oblique Section, and at the last two places brush has also been laid for their further protection.

H. The projected extension of the several jetties on Beach Point and State Dike has been completed.

I. A bulkhead and 6 jetties built for the preservation and protection of the beach at Cove Section, near High Head, where encroached upon by the extraordinary gales of November, 1873, and January, 1874. This bulkhead is 607 feet in length, and the jetties have an aggregate length of 126 feet. They consist of a frame-work filled with brush and ballasted with stone, and were completed in December, 1874.

J. Accurate resurveys made in 1871–'72–'73–'74, and '75 of Cove Section, Oblique Section, Beach Point, and Long Point, together with elaborate soundings and current observations in the inner harbor.

The only work of those projected for the preservation and improvement of this harbor, that now remains to be completed, is the stone bulkhead on Long Point; and contracts have been made for its com-

pletion during the present season, under the appropriation made therefor by the river and harbor act of August 14, 1876.

The amount expended during the fiscal year ending June 30, 1877, has been applied to extending the stone bulkhead on Long Point, and planting beach-grass at Cove Section and High Head Dike.

These works and all the others built for the preservation and protection of this harbor require continuous watching and repairs, for which the additional sum of $1,000 will be required for the next fiscal year.

July 1, 1876, amount available	$496 07	
Amount appropriated by act approved August 14, 1876	4,000 00	
		$4,496 07
July 1, 1877, amount expended during fiscal year	437 40	
July 1, 1877, outstanding liabilities	888 00	
		1,325 40
July 1, 1877, amount available		3,170 67
Amount (estimated) required for completion of existing project		1,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		1,000 00

(See Appendix A 14.)

IMPROVEMENT OF HARBORS AND RIVERS ON THE SOUTHERN COAST OF MASSACHUSETTS AND IN RHODE ISLAND—IMPROVEMENT OF CONNECTICUT RIVER.

Officer in charge, Major G. K. Warren, Corps of Engineers, with Capt. D. P. Heap, Corps of Engineers, under his immediate orders since April 25, 1877.

1. *Hyannis Harbor, Massachusetts.*—Nothing has been done at this place for want of funds. An appropriation of $10,000 is necessary to complete the strengthening of the breakwater.

July 1, 1876, amount available	$42 94
July 1, 1877, amount available	42 94
Amount (estimated) required for completion of existing project	10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	10,000 00

(See Appendix B 1.)

2. *Wareham Harbor, Massachusetts.*—The improvement designed for this harbor consisted mainly in dredging the channel of approach to a depth of 9 feet at mean low-water, and in widening and straightening it. This has been completed during the past fiscal year to an extent greater than was designed, owing to a reduction in the cost of dredging. With the unexpended balance it is proposed to build sand-catchers upon Long Beach, to arrest the sand which drifts over the beach into the harbor.

Nine feet at mean low-water, or $12\frac{9}{10}$ feet at mean high-water, can now be carried by vessels up to the wharves, and the width is nowhere less than 100 feet, gradually widening from the wharves outward.

July 1, 1876, amount available	$7,024 78
July 1, 1877, amount expended during fiscal year	4,967 04
July 1, 1877, amount available	2,057 74

(See Appendix B 2.)

3. *New Bedford Harbor, Massachusetts.*—No work was done here during the past fiscal year for want of funds, as the appropriation of $10,000 in the River and Harbor act of August 14, 1876, was not made available until April 30, 1877.

A contract has been entered into for dredging, and at so low a price that it is thought the projected channel of 200 feet width and 15

feet depth at mean low-water can be completed with the funds now available.

July 1, 1876, amount available	$73 87
Amount appropriated by act approved August 14, 1876	10,000 00
	10,073 87
July 1, 1877, amount expended during fiscal year	419 27
July 1, 1877, amount available	9,654 60

(See Appendix B 3.)

4. *Taunton River, Massachusetts.*—During the fiscal year 93 cubic yards of rocks were removed from "The Nook" and Peters Point. An appropriation of $5,000 is needed to complete the channel of 60 feet width and 9 feet depth at mean high-water.

July 1, 1876, amount available	$1,205 90
July 1, 1877, amount expended during fiscal year	1,104 97
July 1, 1877, amount available	100 93
Amount (estimated) required for completion of existing project	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	5,000 00

(See Appendix B 4.)

5. *Fall River Harbor, Massachusetts.*—No work was done here during the fiscal year for want of funds. A contract has been made to continue the dredging with the appropriation of $10,000 of the act of August 14, 1876, which, it is thought, will complete the improvement to the extent originally designed. This improvement is for the benefit of the commerce of the port, and probably nothing more is needed at present. The fall in prices has enabled the Government to do the work at much lower rates than at first anticipated.

The estimate was $45,000. The appropriations have amounted to $30,000.

July 1, 1876, amount available	$597 55
Amount appropriated by act approved August 14, 1876	10,000 00
	10,597 55
July 1, 1877, amount expended during fiscal year	341 08
July 1, 1877, amount available	10,256 47

(See Appendix B 5.)

6. *Pawtucket or Seekonk River, Rhode Island.*—No work has been done during the fiscal year, and none will be done this season, unless the shoals become troublesome, or some accidental obstruction occurs.

July 1, 1876, amount available	$1,594 61
July 1, 1877, amount expended during fiscal year	83 33
July 1, 1877, amount available	1,511 28

(See Appendix B 6.)

7. *Bulkhead Rock, Providence River, Rhode Island.*—This rock is a dangerous and annoying obstruction to all vessels entering or leaving the port of Providence drawing more than 14 feet. It was removed down to 14 feet at mean low-water under an appropriation made in 1870. A depth of 18 feet at mean low-water is deemed to be necessary, to make which it is estimated will require an appropriation of $5,000.

July 1, 1876, amount available	$74 98
July 1, 1877, amount available	74 98
Amount (estimated) required for completion of existing project	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	5,000 00

(See Appendix B 7.)

8. *Newport Harbor, Rhode Island.*—With a small balance of the appropriation of March 3, 1875, and the assistance of the officers of the United States Navy torpedo-station and those of the Old Colony Steamboat Company, two large bowlders were removed from the channel. These bowlders had been struck several times at extreme low tides by the large steamboats, and during the last year caused considerable damage. The improvement planned at this place was designed to facilitate business at the port, and not to increase its capacity as a harbor of refuge. With this view all has been done that is now needed.

July 1, 1876, amount available	$954 06
July 1, 1877, amount expended during fiscal year	923 92
July 1, 1877, amount available	30 14

(See Appendix B 8.)

9. *Block Island Harbor, Rhode Island.*—Work has been commenced on the proposed detached pier under the appropriation made by act of August 14, 1876. The funds now available will complete the breakwater designed for the business of the island.

The harbor has become the resort of numbers of fishing-vessels belonging elsewhere, so that at times it is quite filled up. It will undoubtedly be sought by fishermen and ordinary coasters in numbers sufficient to fill a harbor of several times its capacity. The present work was not designed to meet this want. At the close of the season's work a final report will be made, which will include plans and estimates of cost of meeting the probable wants of the future.

July 1, 1876, amount available	$22,447 70	
Amount appropriated by act approved August 14, 1876	40,000 00	
		$62,447 70
July 1, 1877, amount expended during fiscal year	13,136 07	
July 1, 1877, outstanding liabilities	2,332 67	
		15,468 74
July 1, 1877, amount available		46,978 96

(See Appendix B 9.)

10. *Pawcatuck River, Rhode Island and Connecticut.*—This improvement as projected has been completed, and no further work is now contemplated. The small balance is reserved to remove any small obstruction that may by accident be placed in the channel.

July 1, 1876, amount available	$176 37
July 1, 1877, amount expended during fiscal year	74 40
July 1, 1877, amount available	101 97

(See Appendix B 10.)

11. *Little Narragansett Bay, Rhode Island and Connecticut.*—The improvement projected for this locality is to open a channel 200 feet wide and 7½ feet deep at mean low-water along the north shore of the bay, by dredging and by removing such rocks as may be found in the way.

The original estimate for the work was $51,000. Deducting $5,000 already appropriated leaves $46,000 still required to complete the work. One-half of this amount could be advantageously expended during the next fiscal year, and would probably suffice to open a channel 100 feet wide, and thus utilize the improvement of Pawcatuck River, which was completed last year.

Amount appropriated by act approved August 14, 1876	$5,000 00
July 1, 1877, amount available	5,000 00
Amount (estimated) required for completion of existing project	46,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	23,000 00

(See Appendix B 11.)

12. *Connecticut River below Hartford, Connecticut.*—Early in the season of 1876 the navigation of this river was much obstructed by shoal water on the bars at Hartford, Clay Banks, Pistol Point, and Glastonbury.

There being no funds available for this improvement, the Hartford and New York Steamboat Company put a dredge to work on June 26, and kept it at work until September 20.

During the months of October, November, and December, 1876, some repairs were made to the west jetty, and several clusters of piles were put in about the head and east side of it to keep vessels off the stone-work. The beacon at the head was rebuilt, but again carried away by a steamer running into it.

Early in May, 1877, water becoming low, vessels began to have trouble in getting over the bars, and a dredge with necessary scows and tug was hired to work by the day. This dredge was at work at the end of the fiscal year.

A schooner wrecked on the bar at the mouth of the river last October having become a dangerous obstruction, a contract was made for its removal. The amount remaining on hand after the removal of this wreck, and doing the required dredging, will be too small to do much toward the completion of the improvement at the mouth of the river; it will therefore be reserved to remove any obstructions, such as shoals or wrecks.

The officer in charge estimates that to complete the jetties at the mouth $45,000 will be required.

July 1, 1876, amount available	$165 42
Amount appropriated by act approved August 14, 1876	20,000 00
	20,165 42
July 1, 1877, amount expended during fiscal year	9,451 67
July 1, 1877, amount available	10,713 75
Amount (estimated) required for completion of existing project	45,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	45,000 00

(See Appendix B 12.)

13. *Connecticut River above Hartford, Connecticut, and below Holyoke, Massachusetts.*—The condition of this part of the river has been such during the past fiscal year that no expenditure for its improvement has been necessary. There is no liability of the existing navigation being injured by shoals, except between Hartford and Enfield Falls. The available funds will be used for their removal, and they are deemed more than sufficient to meet any such contingency.

It is recommended that the report giving results of surveys, with the maps and diagrams, be published, so that the exact nature of the condition of navigation on the river may be made known. Its capacity is limited now by the size of the canal around Enfield Falls, and unless these falls are radically improved, at a cost of from $800,000 to $900,000, but little can be done to increase the draft and tonnage of vessels destined for Holyoke.

If the improvement of these falls is not contemplated, it is recommended that all the money appropriated (reserving $5,000 for the shoals between Hartford and Enfield Falls) should be used in publishing the detailed reports and in carrying on the improvement of the bar at the mouth of the river.

Above Hartford, Conn., and below Holyoke, Mass.

(Act of March 3, 1871.)

Amount available July 1, 1876	$3,831 83
Amount expended during fiscal year ending June 30, 1877	541 40
Amount available July 1, 1877	3,290 43

Above Enfield Falls, Conn., and below Holyoke, Mass.

(Act of June 10, 1872.)

Amount available July 1, 1876	$10,702 92
Amount available July 1, 1877	10,702 92

Above Hartford and below Enfield Falls, Conn.

(Act of March 3, 1873.)

Amount available July 1, 1876	$12,272 04
Amount available July 1, 1877	12,272 04

(See Appendix B 13.)

HARBORS ON LONG ISLAND SOUND.

Officer in charge, Maj. J. W. Barlow, Corps of Engineers.

1. *Stonington Harbor, Connecticut.*—With the funds available July 1, 1875, the breakwater on Wampassett Shoal was commenced and carried to a length of 771 feet, but no appropriation having been made for the year ending June 30, 1877, the construction of the breakwater has been suspended. It is desirable that work be resumed at an early day, for which purpose $50,000 could be profitably expended during the ensuing fiscal year.

July 1, 1876, amount available	$959 75
July 1, 1877, amount expended during fiscal year	915 12
July 1, 1877, amount available	44 63
Amount (estimated) required for completion of existing project	206,536 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	50,000 00

(See Appendix C 1.)

2. *Thames River, Connecticut.*—The sum of $6,000 can be profitably expended during the next fiscal year toward the removal of certain shoals which have formed in the dredged channel of this river, completed to a depth of 11 feet in 1873.

(See Appendix C 2.)

3. *New Haven Harbor, Connecticut.*—Under an extension of the contract of 1876 for dredging in this harbor, work has been continued between Long Wharf and Belle Dock, making this part of the harbor 415 feet wide and 13 feet deep at mean low-water. The officer in charge recommends that the portion of the harbor between Fort Hale and the steamboat dock be widened to 400 feet to correspond to the width above, and be carried to a depth of 16 feet at mean low-water. An appropriation of $40,000 is asked by him for this purpose, which could be profitably expended during the next fiscal year.

No work has been done at Luddington Rock, the contractor having declined to go on with the excavation.

The least depth is 12.4 feet at mean low-water where a can-buoy marks the obstruction. Owing to the proximity of the new light-house on

Southwest Ledge, the rock is now a much less serious obstacle to navigation than formerly.

July 1, 1876, amount available	$11,697 34
July 1, 1877, amount expended during fiscal year	9,085 21
July 1, 1877, amount available	2,612 13

(See Appendix C 3.)

4. *Milford Harbor, Connecticut.*—The dredging in progress at the close of the last fiscal year was continued under an extension of the contract, and the channel 75 feet wide and 4 feet deep at mean low-water was carried 800 feet above the long jetty. The officer in charge suggests that a channel 50 feet wide be continued to the town docks, the cost of which would be $9,000.

The small jetties built to protect the the bluff north of Welch's Point have been much injured by storms. The officer in charge deems it advisable to build a substantial jetty from Welch's Point to deep water. This would aid in protecting the bluff from erosion, and form a much needed harbor of refuge.

To continue dredging in upper harbor, and to commence jetty at Welch's Point, the sum of $25,000 could be advantageously applied during the next fiscal year.

July 1, 1876, amount available	$4,706 65
July 1, 1877, amount expended during fiscal year	4,260 81
July 1, 1877, amount available	445 84
Amount (estimated) required for completion of existing project	64,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	25,000 00

(See Appendix C 4.)

5. *Housatonic River, Connecticut.*—The work of dredging the bars near Drew's Rock was continued. The 7-foot channel obstructed by freshets was restored, and made from 45 to 80 feet wide. Five thousand dollars will be needed to remove deposits likely to have formed during the winter and spring freshets.

July 1, 1876, amount available	$4,460 11
July 1, 1877, amount expended during fiscal year	4,442 38
July 1, 1877, amount available	17 73
Amount that can be profitably expended in fiscal year ending June 30, 1879	5,000 00

(See Appendix C 5.)

6. *Bridgeport Harbor, Connecticut.*—The sum of $10,000 appropriated by act of August 14, 1876, will be applied to excavation between the steamboat-wharf and the wagon-bridge. A contract has been made to do this dredging at 8¾ cents per cubic yard; the whole work to be completed by the 1st of October, 1877.

The officer in charge asks for an appropriation of $20,000, to be applied to widening to 200 feet the 12-foot channel over the outer and inner bars, now 100 feet in width.

July 1, 1876, amount available	$54 85	
Amount appropriated by act approved August 14, 1876	10,000 00	
		$10,054 85
July 1, 1877, amount expended during fiscal year		167 90
July 1, 1877, amount available		9,886 95
Amount (estimated) required for completion of existing project		40,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		20,000 00

(See Appendix C 6.)

7. *Southport Harbor, Connecticut.*—With the appropriation of $5,000 made by act of August 14, 1876, it is proposed to repair the breakwater and dike during the present season.

The officer in charge asks for an appropriation of $8,000 to deepen the channel to 4 feet at mean low-water by dredging.

July 1, 1876, amount available	$383 99
Amount appropriated by act approved August 14, 1876	5,000 00
	5,383 99
July 1, 1877, amount expended during fiscal year	320 06
July 1, 1877, amount available	5,063 93

(See Appendix C 7.)

8. *Norwalk River, Connecticut.*—No appropriation having been made for this improvement during the past fiscal year, work has been suspended.

The officer in charge estimates that it will require $30,000 to complete the channel to the desired dimensions, and recommends that $15,000 for this purpose be appropriated for the next fiscal year.

July 1, 1876, amount available	$190 62
July 1, 1877, amount expended during fiscal year	190 62
Amount (estimated) required for completion of existing project	30,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	15,000 00

(See Appendix C 8.)

9. *Port Jefferson Harbor, New York.*—The construction of the west jetty in progress at the close of the last fiscal year was continued. This jetty is now 475 feet in length, and should be extended 600 feet farther to produce the desired effect upon the tidal currents.

The work of repairing, raising, and extending the east side jetty has been commenced, and it is also proposed to dredge a channel 50 feet wide across the bar. To further extend the jetties, and to widen the channel to 100 feet, an estimate of $34,000 is submitted by the officer in charge, of which $20,000 can be expended to advantage during the next fiscal year.

July 1, 1876, amount available	$11,006 23
Amount appropriated by act approved August 14, 1876	6,000 00
	17,006 23
July 1, 1877, amount expended during fiscal year	5,744 59
July 1, 1877, amount available	11,261 64
Amount (estimated) required for completion of existing project	34,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	20,000 00

(See Appendix C 9.)

IMPROVEMENT OF HUDSON RIVER—REMOVAL OF OBSTRUCTIONS IN EAST RIVER, INCLUDING HELL GATE—IMPROVEMENT OF HARLEM RIVER AND EAST CHESTER CREEK, AND OF THE HARBORS OF PORT CHESTER AND RONDOUT, IN NEW YORK; PASSAIC RIVER AND THE CHANNEL BETWEEN STATEN ISLAND AND FEW JERSEY; HARBORS ON LAKE CHAMPLAIN.

Officer in charge, Lieut. Col. John Newton, Corps of Engineers, who has under his immediate orders Captain James Mercur and Lieut. J. H. Willard, Corps of Engineers.

In temporary charge of Captain Mercur since April 18, 1877, in the absence of Lieut. Col. Newton.

1. *Improvement of Hudson River, New York.*—Surveys were made during the fiscal year of sloop-lock, from Port Schuyler to Bath, at Overslaugh, Overslaugh dam, Winnie's Bar, from Cedar Hill to Nine-mile tree, at Mull's, Mull's Rock, Coeymans, New Baltimore and New Baltimore Rocks, and maps of the same prepared.

Of the new dike on the Overslaugh, 1,000 feet were finished and 2,000 feet are in course of construction; of cross-dike, 424 feet have been finished and 1,220 feet partly so.

The dredging consisted of 1,900 cubic yards on the Overslaugh and 136,709 by the State engineer between the State dam at Troy and New Baltimore.

Repairs were made to the dikes at New Baltimore, Coeymans, Overslaugh, Small Island, Bath, Patroon's, and Port Schuyler, which had been more or less injured by ice during the winter.

July 1, 1876, amount available	$5,515 09	
Amount appropriated by act approved August 14, 1876	50,000 00	
		$55,515 09
July 1, 1877, amount expended during fiscal year	18,654 67	
July 1, 1877, outstanding liabilities	9,876 00	
		$28,530 67
July 1, 1877, amount available		26,984 42
Amount (estimated) required for completion of existing project		164,116 47
Amount that can be profitably expended in fiscal year ending June 30, 1879		126,000 00

(See Appendix D 1.)

2. *Removing obstructions in East River and Hell Gate, New York, (Hallet's Point.)*—On August 6, 1876, the work preparatory for the final blast was commenced and carried forward until September 24, at which date the mine was exploded with complete success.

After the blast contract was made for the removal by dredging of about 24,000 tons of broken rock, and at the end of the year 14,055 tons had been removed.

A preliminary report of the operations connected with the destruction of the reef at Hallet's Point was made by Lieutenant-Colonel Newton, the officer in charge, in December, 1876, which was submitted by the Secretary of War to the House of Representatives January 13, 1877, and printed as House Ex. Doc. No. 24, Forty-fourth Congress, second session. (See Appendix D 2.)

A detailed report of the entire progress of the work from its inception is now in course of preparation under Colonel Newton's supervision, and will be submitted as soon as completed.

Flood Rock.—Work was stopped on May 26, 1876, and was not resumed until September 30, 1876, and continued until December 31, 1876, when the heavy ice running in the river rendered it impossible to continue regular work; the pumps and machinery were therefore removed from the mine and it was allowed to fill with water.

Number of feet of holes drilled	13,311
Number of holes blasted	3,303
Number of drills sharpened	1,777
Loss of steel by abrasion, pounds	178
Number of cubic yards of rock removed	1,772.2

No appropriation having been made at the last session of Congress, it became necessary to suspend operations on this work.

Steam drilling-scow.—From July 1 to September 28, 1876, the crew of the scow was employed in assisting at the preparations for the final blast at Hallet's Point.

From October 19, 1876, to December 23, 1876, the scow was engaged

on Diamond Reef; work was suspended in consequence of having no funds for continuing it.

Cubic yards of rock removed	916.25
Number of drill-hole blasts made	16
Number of holes drilled	185
Number of feet drilled	1,997.8
Vulcan powder used, pounds	14,244
Average depth of hole drilled, feet	10.8

July 1, 1876, amount available	$54,141 46	
Amount appropriated by act approved August 14, 1876	250,000 00	
		$304,141 46
July 1, 1877, amount expended during fiscal year	180,936 68	
July 1, 1877, outstanding liabilities	3,373 34	
		184,310 02
July 1, 1877, amount available		119,831 44
Amount (estimated) required for completion of existing project		3,213,127 55
Amount that can be profitably expended in fiscal year ending June 30, 1879		600,000 00

(See Appendix D 2.)

3. *Dredging mud bars in Hudson River, opposite Jersey City.*—No work was done during the year. An examination and survey of that portion of the river dredged during the years 1875 and 1876 shows that at least two-thirds of the amount excavated has been replaced by the action of the currents; leaving nearly the same depth of water as existed before the dredging was done.

No further dredging is recommended until some plan of improvement which gives promise of being permanent is devised.

July 1, 1876, amount available	$101 05
July 1, 1877, amount expended during fiscal year	101 05
Amount (estimated) required for completion of existing project	76,807 20

(See Appendix D 3.)

4. *Improvement of Harlem River, New York.*—No appropriation having been made for this work, no operations were conducted during the year.

Amount (estimated) required for completion of existing project	$146,875 56
Amount that can be profitably expended in fiscal year ending June 30, 1879	50,000 00

(See Appendix D 4.)

5. *Improvement of Passaic River, New Jersey.*—Work was commenced in May, 1877, for the removal of loose stones and bowlders from the sides of the cut at Rutherford Park bar, and up to the close of the year 395 cubic yards of stone had been removed and 685 feet of channel cleared.

July 1, 1876, amount available	$463 47
Amount appropriated by act approved August 14, 1876	10,000 00
	10,463 47
July 1, 1877, amount expended during fiscal year	1,898 01
July 1, 1877, amount available	8,565 46
Amount (estimated) required for completion of existing project	24,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	24,000 00

(See Appendix D 5.)

6. *Improvement of East Chester Creek, New York.*—The State commissioners appointed to purchase and condemn the marsh land through which the proposed channel runs having completed their labor, and secured to the United States the necessary ground and right of way, contract was made for dredging, piling, and rock excavation, and on April 16, 1877, work was commenced, and has progressed as favorably as the

circumstances would allow; 906 cubic yards of rock have been removed, and 5,936 cubic yards of mud dredged.

July 1, 1876, amount available		$30,820 82
July 1, 1877, amount expended during fiscal year	$1,101 95	
July 1, 1877, outstanding liabilities	1,010 46	
		2,112 41
July 1, 1877, amount available		28,708 41
Amount (estimated) required for completion of existing project		99,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		35,000 00

(See Appendix D 6.)

7. *Improvement of harbor at Port Chester, New York.*—No appropriation having been made for this work, no operations were conducted during the year.

July 1, 1876, amount available	$2,236 70
July 1, 1877, amount expended during fiscal year	36 70
July 1, 1877, amount available	2,200 00
Amount (estimated) required for completion of existing project	84,632 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	60,000 00

(See Appendix D 7.)

8. *Improvement of harbor at Rondout, New York.*—During the winter of 1876 and 1877 the ice destroyed about 200 feet of the north dike and caused considerable damage to other portions of the dike; this damage was repaired by hired labor.

Under appropriation of August 14, 1876, contract was made for the construction of the branch dike 870 feet long, and work was commenced about June 20, 1877.

July 1, 1876, amount available	$9 31	
Amount appropriated by act approved August 14, 1876	30,000 00	
		$30,009 31
July 1, 1877, amount expended during fiscal year	6,719 54	
July 1, 1877, outstanding liabilities	5,193 90	
		11,913 44
July 1, 1877, amount available		18,095 87
Amount (estimated) required for completion of existing project		$111,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		70,000 00

(See Appendix D 8.)

9. *Improving the channel between Staten Island and New Jersey.*—No work has been done at this point during the year. Efforts are now being made to find out from those most largely interested in the improvement of this channel, what, in their opinion, the needs of commerce require.

July 1, 1876, amount available	$229 74
Amount appropriated by act approved August 14, 1876	10,000 00
	10,229 74
July 1, 1877, amount available	10,229 74
Amount (estimated) required for completion of existing project	30,480 00

(See Appendix D 9.)

10. *Improvement of harbor of Plattsburgh, New York.*—During the year no operations have been conducted.

July 1, 1876, amount available	$4,941 52
July 1, 1877, amount available	4,941 52

(See Appendix D 10.)

11. *Improvement of harbor at Burlington, Vermont.*—The superstructure of the extension of 160 feet of breakwater has been completed, and work on the repairs to the southern end of the breakwater has been commenced and carried up to within two courses of the necessary height.

July 1, 1876, amount available	$7,590 71
Amount appropriated by act approved August 14, 1876	20,000 00
	27,590 71
July 1, 1877, amount expended during fiscal year	12,113 56
July 1, 1877, amount available	15,477 15
Amount (estimated) required for completion of existing project	295,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	50,000 00

(See Appendix D 11.)

12. *Improvement of harbor at Swanton, Vermont.*—The superstructure of an extension of 69 feet of breakwater has been completed.

No new work has been commenced under the appropriation of August 14, 1876, of $2,000, as the amount is not sufficient to build a crib large enough to withstand the ice-pressure brought against this work in the spring.

July 1, 1876, amount available	$3,411 85
Amount appropriated by act approved August 14, 1876	2,000 00
	5,411 85
July 1, 1877, amount expended during fiscal year	2,801 20
July 1, 1877, amount available	2,610 65
Amount (estimated) required for completion of existing project	237,160 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	50,000 00

(See Appendix D 12.)

13. *Improvement of Otter Creek, Vermont.*—No appropriation having been made, no operations were conducted during the year.

July 1, 1876, amount available	$63 69
July 1, 1877, amount expended during fiscal year	7 85
July 1, 1877, amount available	55 84
Amount (estimated) required for completion of existing project	43,146 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	20,000 00

(See Appendix D 13.)

CONSTRUCTION OF PIER AT LEWES, DELAWARE—HARBOR IMPROVEMENTS ON DELAWARE RIVER AND BAY—IMPROVEMENT OF THE NAVIGATION OF DELAWARE AND SCHUYLKILL RIVERS; OF BROADKILN RIVER, DELAWARE; AND OF SHREWSBURY RIVER AND COHANSEY CREEK, NEW JERSEY—DELAWARE BREAKWATER HARBOR.

Officer in charge, Lieut. Col. J. D. Kurtz, Corps of Engineers, with Capt. William Ludlow, Corps of Engineers, under his immediate orders.

1. *Construction of pier near Lewes, Delaware.*—During the last fiscal year a steam-engine has been purchased as the motive power on the construction of the pier; two bays have been constructed of material left on hand in the fall of 1875, and twenty more pile-shafts, with the neces-

sary parts, have been ordered from the lowest bidders for supplying the material.

During the present fiscal year it is proposed to put in place all of this material, and to put down a corresponding portion of the timber superstructure. This will make the entire length of the structure 1,659 feet.

Next year it is proposed to complete the work by finishing the outer end; by surrounding the pier-head with a suitable fender system; by placing buoyed anchors for vessels to moor to when lying at the pier; and by laying a railroad-track 2,700 feet long on the pier and to the limit of the United States land, to enable the railroads of the locality to connect with and use the landing pier.

July 1, 1876, amount available	$75 43	
Amount appropriated by act approved August 14, 1876	30,000 00	
		$30,075 43
July 1, 1877, amount expended during fiscal year	9,253 80	
July 1, 1877, outstanding liabilities	9,500 00	
		18,753 80
July 1, 1877, amount available		11,321 63
Amount (estimated) required for completion of existing project		50,600 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		50,600 00

(See Appendix E 1.)

2. *Ice-harbor at New Castle, Delaware.*—A contract for the removal of 110 feet in length of the coal wharf below the piers, in addition to the 108 feet removed last year, has been executed and the work commenced.

The construction of the crib foundation of a new ice-pier, the last contemplated by the present plan of improvement, will be completed the present year, leaving the platform of the crib at the level of low water in readiness for the stone superstructure.

Next year it is proposed to complete this pier and dredge out the accumulated sediment in the lower part of the harbor, for which purpose an appropriation of $24,000 is asked by the officer in charge.

July 1, 1876, amount available	$3,094 40
Amount appropriated by act approved August 14, 1876	12,000 00
	15,094 40
July 1, 1877, amount expended during fiscal year	676 13
July 1, 1878, amount available	14,418 27
Amount (estimated) required for completion of existing project	28,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1879..	24,000 00

(See Appendix E 2.)

3. *Harbor of Wilmington, Delaware.*—During the past year work has been in progress along the channel of the river just above the light-house; just below the mouth of Brandywine Creek; just above Third street on the north, and above Market street on the south side of channel. The result has been the removal of soft mud deposits, and an increase in the width of the channel in each case, affording 12 feet depth of water at low tide. The amount of material removed was 88,000 cubic yards.

It is proposed the present season to remove from the channel-way near the mouth of the Brandywine Creek about 5,000 cubic yards of mud, and from the south side of channel just below Third street about 210 cubic yards of fast rock.

Next season it is proposed to remove, by dredging between a point

near the buoy depot and Market street, about 80,000 cubic yards of material. This will require an appropriation of $17,000.

July 1, 1876, amount available	$120 29	
Amount appropriated by act approved August 14, 1876	16,000 00	
		$16,120 29
July 1, 1877, amount expended during fiscal year	3,606 48	
July 1, 1877, outstanding liabilities	5,932 80	
		9,539 28
July 1, 1877, amount available		6,581 01
Amount (estimated) required for completion of existing project		20,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		17,000 00

(See Appendix E 3.)

4. *Harbor at Marcus Hook, Pennsylvania.*—There has been no material change in the condition of this harbor during the past year. During the winter about 208 vessels, mostly large ones, took shelter here from heavy floating ice.

During the present season it will be advisable to make repairs to the two landing-piers, the upper timbers of which are fast going to decay. These repairs, together with slight repairs that are requisite to the upper stone ice-pier, will require an expenditure of about $2,200.

It is proposed to examine these piers with a view of placing a rock protection about their bases, if required.

July 1, 1876, amount available	$6,701 91
July 1, 1877, amount expended during fiscal year	359 00
July 1, 1877, amount available	6,342 91

(See Appendix E 4.)

5. *Ice-harbor at Chester, Pennsylvania.*—During the fiscal year ending June 30, 1877, repairs have been made to the upper ice-piers and bulkhead, and the connecting bridges were reconstructed. The work was done by hired labor and purchase of material in open market, at a cost of $2,600.

This harbor was of much benefit to vessels the past winter. It afforded shelter to 25 large-class schooners, several tug-boats, barges, and other floating property.

Amount appropriated by act approved August 14, 1876	$2,600 00
July 1, 1877, amount expended during fiscal year	2,600 00

(See Appendix E 5.)

6. *Improvement of Schuylkill River, Pennsylvania.*—During the past year operations for improving this river have been confined to the mouth and vicinity upward toward Girard Point, with a view of deepening the channel to 24 feet at ordinary low tide. About 50,000 cubic yards of material have been removed.

During the present season it is proposed to continue the dredging at the mouth of the river, increasing the width of the deep-water channel with each cut; and remove about 18,000 cubic yards of material from the channel near Gibson's Point, so as to afford 20 feet depth of water at low tide.

Next year it is proposed to complete the deep channel at the mouth; remove 3,000 cubic yards of gravel from the cut just above Penrose Ferry bridge; remove about 400 cubic yards of fast rock from the channel at Gibson's Point, and 50,000 cubic yards of sand and gravel from the channel between "Gibson's" and Gray's Ferry bridge, the latter work

to be executed with a view of affording 18 feet depth of water at low tide above Gibson's Point.

July 1, 1876, amount available	$99 85	
Amount appropriated by act approved August 14, 1876	20,000 00	
		$20,099 85
July 1, 1877, amount expended during fiscal year	6,096 06	
July 1, 1877, outstanding liabilities	2,534 71	
		8,630 77
July 1, 1877, amount available		11,469 08
Amount (estimated) required for completion of existing project		209,700 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		65,000 00

(See Appendix E 6.)

7. *Improvement of Delaware River below Petty's Island.*—During the fiscal year ending June 30, 1877, operations have been directed to the improvement of the navigation of the river at Fort Mifflin Bar, where the artificial cut has been widened at the entrance to the New Jersey channel by the removal of about 100,000 cubic yards of sand, and to the removal of a wreck sunk at a point just below the Horseshoe Buoy.

During the present season it is proposed to complete the excavation at the south end, at Fort Mifflin Bar; to commence and complete additional excavations at the north end of the channel, with a view of widening the same at the entrance to the Pennsylvania channel, which will require the removal of about 50,000 cubic yards of material; to remove a wreck from the channel just above Pea-Patch Island, and one from the channel just above the "Buoy of the Middle," Delaware Bay; to resume the improvement of the channel upon the northern and western side at Bulkhead Shoals, and to survey the locality of the improved channel at Fort Mifflin Bar.

Next season it is proposed to continue the removal of shoal points along the easterly side of Bulkhead Channel, lower down the river.

Amount appropriated by act approved August 14, 1876		$40,000 00
July 1, 1877, amount expended during fiscal year	$14,163 95	
July 1, 1877, outstanding liabilities	5,162 08	
		19,326 03
July 1, 1877, amount available		20,673 97
Amount (estimated) required for completion of existing project		235,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		100,000 00

(See Appendix E 7.)

8. *Improvement of Delaware River, between Trenton and White Hill, New Jersey.*—Operations for improving the river at this locality closed in the fall of 1875, owing to the exhaustion of the appropriation. A channel had then been made around Periwig Island 125 feet in width and 6 feet depth of water at low tide.

Next year it is proposed, should an appropriation be made, to continue the improvement at the same locality, in maintaining its depth and increasing its width.

Amount (estimated) required for completion of existing project	$30,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	10,000 00

(See Appendix E 8.)

9. *Improvement of Broadkiln River, Delaware.*—Operations for the improvement of this river ceased in the spring of 1874.

Should an appropriation be made, it is proposed next year to continue the work by dredging the river at the shoal places, and excavat-

ing an inlet into the bay at the junction of the Broadkiln and Lewes Creeks.

Amount (estimated) required for completion of existing project..........	$70,447 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	10,000 00

(See Appendix E 9.)

10. *Improvement of the north and south branches of the Shrewsbury River, New Jersey.*—Operations for improving this river ceased in 1873, for want of funds.

Should an appropriation be made, work will resume next season by dredging at Upper and Lower Rocky Points, and by constructing a deflecting dike at the latter point.

Amount (estimated) required for completion of existing project..........	$18,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	18,000 00

(See Appendix E 10.)

11. *Improvement of Cohansey Creek, New Jersey.*—No appropriation was made for the fiscal years ending June 30, 1875, 1876, and 1877, for continuing this improvement.

An appropriation is recommended by the officer in charge for widening and deepening the channel in accordance with the original project for the work.

Amount (estimated) required for completion of existing project...........	$20,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	10,000 00

(See Appendix E 11.)

12. *Delaware Breakwater.*—There is no material change in the condition of this work since my last annual report.

The Western Union Telegraph Company still have a station here, and operate their line, connecting with the land by cable laid along the bottom of the harbor.

The use of the harbor as a port of call for transatlantic shipping is largely increasing, as will be seen by the tabular statement in the appendix.

(See Appendix E 12.)

13. *Port Wardens' Line, Philadelphia, Pennsylvania.*—This question remains as last reported, nothing on the subject having been heard from the municipal authorities of Philadelphia.

Measures for the widening of Delaware avenue have been taken by the councils of the city.

IMPROVEMENT OF HARBORS AND RIVERS OF CHESAPEAKE BAY, MARYLAND; OF JAMES AND APPOMATTOX RIVERS, VIRGINIA; OF GREAT KANAWHA RIVER, WEST VIRGINIA; OF NEW RIVER, VIRGINIA AND WEST VIRGINIA, AND OF CAPE FEAR RIVER, NORTH CAROLINA.

Officer in charge, Maj. William P. Craighill, Corps of Engineers, who has had under his immediate orders during the fiscal year Capt. C. B. Phillips and Lieut. Thomas Turtle, Corps of Engineers, and since November, 1876, Capt. J. W. Cuyler, Corps of Engineers.

1. *Improvement of Chester River at Kent Island Narrows, Maryland.*—The appropriations for this work have been: March 3, 1873, $15,000; June 23, 1874, $5,000; and August 14, 1876, $5,000; but owing to causes of delay, explained in previous reports, nothing was done in carrying out the project until May, 1875.

On the 30th of June, 1876, the portion of the work on the Easton Bay side has been completed, the width of channel having been reduced, however, to 80 feet instead of 100 feet as at first contemplated.

On the Chester River side the channel had been dredged to 80 feet in width over the entire distance, and an additional cut was being made, making the total width 100 feet, as at first proposed. The causeway had also been cut through to the full width (60 feet) allowed by the draw, which had previously been built by the county authorities of Queen Anne and Talbot.

Operations ceased on the 7th of July, 1876, the available funds being exhausted. An examination of the entire channel, made immediately after, indicated that the channel was maintaining itself well, both as to width and depth.

Of the appropriation of $5,000, made August 14, 1876, only $1,000 became available for expenditure in September.

It was proposed to expend this amount at once in giving relief to navigation by cutting through the causeway under the counterpoise of the draw, to give additional vent to the water, by riprapping at the central pier and the abutments, and by the construction of pile-wings at the passage through the draw.

This plan was rendered inexpedient on account of the condition of the causeway, which was badly broken up by the severe storm of September 17, 18.

In April last an examination of the entire channel was made. It was found that it had maintained itself well.

At an inspection of the causeway and draw, made during the early part of June, it was found that the county authorities had put both in a condition sufficiently good to warrant the General Government in going on with the improvement of the channel.

Operations were resumed on the 11th of June, and consisted in cutting out the causeway under the counterpoise of the draw, giving additional vent to the water; in riprapping the central pier and the counterpoise abutment; in the construction of four pile-wings to facilitate the passage of shipping through the draw, and in marking the entire length of the channel with guide-piles.

This work was completed on the 28th of June. Since that date a dredge has been engaged by the day for cutting off some sharp turns in the channel, particularly on the Easton Bay side of the causeway. It is proposed to continue this dredging as long as available funds will permit.

The balance ($4,000) of the appropriation of August 14, 1876, was rendered available on March 31 last.

The original estimate for this improvement was $23,000. Twenty-five thousand dollars were appropriated in all up to June 30, 1877; but owing to long and unavoidable delays and consequent increase of expenses, this sum has not quite completed the work estimated for.

Occasional repairs will be required to keep this channel open when completed. Their cost will probably average $3,000 per year. This amount can be profitably expended in the fiscal year ending June 30, 1879.

July 1, 1876, amount available	$5,374 15
Amount appropriated by act approved August 14, 1876	5,000 00
	10,374 15
July 1, 1877, amount expended during fiscal year	6,340 92
July 1, 1877, amount available	4,033 23
Amount (estimated) required for completion of existing project	3,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	3,000 00

(See Appendix F 1.)

2. *Improvement of the entrance to the harbor of Baltimore, Maryland.*—During the past fiscal year operations have been confined to dredging at the upper end of the Fort McHenry Channel, with a view to widening the entrance to the inner harbor of Baltimore; and at the lower end of the Brewerton Channel, with a view to restoring the original depth of the channel below North Point. On June 30, 1876, work remained suspended, the appropriation having been exhausted early in June.

By act of Congress approved August 14, 1876, an appropriation of $75,000 was made for the work, but none of this amount became available for expenditure until September 14, when an allotment of $40,000 was made.

Examinations of portions of the channel were at once commenced, to ascertain the points most in need of attention. The resulting maps having been prepared, the two points specified above were determined upon as most in need of improvement, and proposals were invited and opened on November 1, for the removal of 240,000 cubic yards of material.

A contract for this amount of dredging was entered into at the rate of 9¾ cents per cubic yard. The contract required the work to be commenced December 1, 1876, but owing to delays caused by an accident to the contractor's machinery while *en route* from the North, and an unprecedented amount of ice in the harbor, operations were not commenced until March 7, 1877. On this date dredging was commenced at the upper end of the Fort McHenry Channel and completed on the 2d of May. Two wedge-shaped pieces were removed, one on either side of the channel, affording a total width of 750 feet opposite Lazaretto Point, the widening commencing about 1,200 feet below. All this dredging was to a depth of 25 feet at ordinary low-water. Ninety-four thousand cubic yards of material were removed from this locality. Dredging was then commenced at the lower end of the Brewerton Channel below North Point. An interior cut 45 feet from the north side of the channel, which was left incomplete in June, 1876, has been completed, and three additional interior cuts have also been made during the balance of the fiscal year, thus conpleting the contract for dredging 240,000 cubic yards, and leaving this portion of the channel, to the extent of five-sevenths of its width, in better condition than ever before, all the dredging being to 25 feet in depth at ordinary low-water.

The balance ($35,000) of the appropriation of August 14, 1876, was rendered available in April last. Proposals were at once invited, and opened on June 1, for the dredging of 300,000 cubic yards of additional material. A contract was entered into for the execution of this amount of work at the rate of 9¼ cents per cubic yard. The contract requires the work to be commenced on July 1, 1877, and to be completed on June 30, 1878. It is proposed to dredge to this extent in completing the deepening of the Brewerton Channel from its lower end as far as opposite North Point; in enlarging the turning place at the junction of Brewerton and Craighill Channels; and in making an entirely new cut through the Brewerton Channel, thus giving an additional width of 40 feet.

The original project for this work contemplated a channel such as would admit of vessels drawing 22½ or 23 feet to come to the city of Baltimore at any ordinary stage of the tide. The object has been attained so far as depth is concerned; but the channel is still deficient in width throughout.

Since the practical completion of the channel in 1874, the annual appropriations have been but little in excess of the amount ($50,000) which it was estimated would be required for annual reparations. All the funds that could be spared for the purpose, however, have been devoted to giving increased width to the channels, particularly at the turning places at their junctions with each other. Considerable relief has thus been afforded to shipping, but more is needed.

No appropriation was made for the coming fiscal year ending June 30, 1878. One hundred and thirty-five thousand dollars were asked for that year, which would have filled the estimated cost of the existing project, and provided for the annual reparations. To this sum add $50,000 for reparations for the year, and we have, as the amount that can be profitably expended in fiscal year ending June 30, 1879, $185,000.

July 1, 1876, amount available	$794 68	
Amount appropriated by act approved August 14, 1876	75,000 00	
		$75,794 68
July 1, 1877, amount expended during fiscal year	20,265 72	
July 1, 1877, outstanding liabilities	9,497 05	
		29,762 77
July 1, 1877, amount available		46,031 91
Amount (estimated) required for completion of existing project		185,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		185,000 00

(See Appendix F 2.)

3. *Improvement of Wicomico River, near Salisbury, Maryland.*—Operations have remained suspended during the whole of the past fiscal year.

The original plan of improvement was to dredge a channel 75 feet in width and 7 feet in depth from the bay up to the town of Salisbury, and deposit the material behind longitudinal dikes. For want of sufficient appropriations, and the unexpected amount of diking required to be done by the Government, the plan was modified so as to contemplate a channel only 50 feet in width and 5 feet in depth. When work was suspended in January, 1876, the appropriation being exhausted, the modified plan had been carried out, with the exception of a short space, which had a width of but 28 feet, for want of funds.

The act of August 14, 1876, appropriated an additional sum of $5,000 for this work, which remained unavailable, however, until March 31, 1877. A re-examination of the channel was made in the early part of May. It was found that the channel had stood quite well, except in the vicinity of the wharves at the town. The shoaling at the latter points appears to be due in a great measure to the deposition of saw-dust from the mills above. The dikes were found to be in good condition.

Arrangements have been made for recommencing work, which will consist in dredging. It is expected that the amount available will be sufficient to give a width of 70 feet to the channel through its entire length, retaining the present depth of 5 feet, and to redredge the turning basin, and in front of the wharves.

It is estimated that from three to four months will be required to execute the work contemplated.

The appropriations have been: June 10, 1872, $5,000; March 3, 1873, $5,000; June 23, 1874, $5,000; March 3, 1875, $5,000; and August 14, 1876, $5,000; total, $25,000.

No appropriation was made for the fiscal year ending June 30, 1878.

Should the original plan be carried out an appropriation of $15,000 will still be required.

July 1, 1876, amount available	$71 04
Amount appropriated by act approved August 14, 1876	5,000 00
	5,071 04
July 1, 1877, amount expended during fiscal year	370 34
July 1, 1877, amount available	4,700 70
Amount (estimated) required for completion of existing project	15,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	7,500 00

(See Appendix F 3.)

4. *Improvement of James River, Virginia.*—Work on this river, which had been suspended in March, 1876, for want of funds, was resumed about the middle of September, 1876, when $40,000 of the appropriation of $60,000 of August 14, 1876, became available for expenditure. No contracts have been made. The work has been partly done with machinery belonging to the United States and partly with machinery belonging to the city of Richmond, which has been hired and operated, as in the previous year, by the United States, the rental not exceeding the cost to the city of necessary repairs.

The following statement shows the cubic yards of material removed: Channel between the Brewery and Almond Creek, earth, 26,655 yards; rock, 727 yards; new channel at Goode's Rocks, earth, 3101 yards; rock, 1302 yards. The city of Richmond has taken about 20,000 yards of earth from the channel below the Brewery, and about 20 yards of rock. There have been removed also by the James River Canal Company and by the Old Dominion Steamship Company about 9,000 yards of sand at their own expense. Three thousand eight hundred and sixty-three linear feet of timber groins have been built at the bars for the purpose of contracting the water-way and by scour producing a greater depth. The experiment of their use on this river has been thus far successful, though its extent has been limited for want of funds.

The Dutch Gap cut-off remains at 180 feet width at the surface of the water, and has a depth of about 15 feet at low-tide. It can be used by all classes of vessels coming to Richmond, but would be improved and made more satisfactory to navigators by a further enlargement.

It is estimated now that the removal of 2,800 cubic yards of sand and gravel would give a channel 100 feet wide and 12½ feet deep at mean low-water from Rockett's Reef to Hampton Roads, which is equivalent to 16 feet at high water; but a greater width and depth are both required for the accommodation of the growing commerce on the river.

July 1, 1876, amount available	$104 59
Amount appropriated by act approved August 14, 1876	60,000 00
	60,104 59
July 1, 1877, amount expended during fiscal year	43,201 67
July 1, 1877, amount available	16,902 92
Amount (estimated) required for completion of existing project	258,024 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	150,000 00

(See Appendix F 4.)

5. *Improvement of the Appomattox River, Virginia.*—The operations of the year have not been extensive. Work for widening the Puddledock

Channel to about 100 feet was completed August 31, 1876, under a contract of December 31, 1875. The cut is now sufficiently wide, under existing circumstances, and has a depth permitting vessels drawing 10½ feet to pass with ease. The old channel of the river is seldom used.

Since the allotment in September, 1876, of $15,000, from the appropriation of $30,000, made August 14, 1876, work has been confined to raising the banks of the new channel at several low places, where the river threatened to break through in high freshets. This was completed in June, 1877. Nothing further seems now necessary for this channel.

Attention will next be given at an early day to the portion of the river between the city of Petersburg and the upper end of the new channel.

July 1, 1876, amount available	$7,613 17
Amount appropriated by act approved August 14, 1876	30,000 00
	37,613 17
July 1, 1877, amount expended during fiscal year	22,042 08
July 1, 1877, amount available	15,571 09
Amount (estimated) required for completion of existing project	83,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	50,000 00

(See Appendix F 5.)

6. *Improvement of Great Kanawha River, West Virginia.*—At the close of the year ending June 30, 1876, the following contracts were in force: August 20, 1875, for building lock No. 5, near Brownston; October 15, 1875, for building lock No. 4, near Cabin Creek Shoal; March 28, 1876, for building the dam, abutment, pier, and floor of a navigation-pass adjoining lock 5.

An additional appropriation of $270,000 was made by the act of August 14, 1876, of which $15,000 became available in September, 1876, $170,000 in January, 1877, and the remaining $85,000 in March, 1877. Additional contracts were made thereafter, as follows: May 1, 1877, for building a dam, abutment, pier, and floor of a navigation-pass adjoining lock No. 4; and May 23, 1877, for the iron-work of the pass and wier of dam 5.

Owing to an unusual frequency of freshets, the working season of 1876 was much shortened, and operations proportionally delayed. Advantage was, however, taken of every suitable day to lay masonry in the foundations. Much stone and other material has been prepared and is in readiness for introduction into the structures, and it is certainly expected that they will be well advanced before the close of 1877, unless there should be a recurrence of the freshets which were so frequent in 1876.

Negotiations are in progress, under the direction of the United States district attorney for West Virginia, for the acquisition of the necessary site for lock and dam No. 3, near the mouth of Paint Creek.

In continuation of the plan of ameliorating the condition of some of the worst shoals which obstruct navigation at points not affected by the permanent works now in hand, a small sum has been expended at Red House Shoal. It has not been considered necessary or expedient to make expenditure of this kind at any other point.

A series of observations have been made at several points on the New River below the mouth of the Greenbrier, for the purpose of determining the effect of freshets in the New River upon the regimen of the

Kanawha. Some observations have also been made on the Elk River with a similar object.

July 1, 1876, amount available	$271,460 49	
Amount appropriated by act approved August 14, 1876	270,000 00	
		$541,460 49
July 1, 1877, amount expended during fiscal year	93,875 85	
July 1, 1877, outstanding liabilities	25,266 47	
		119,142 32
July 1, 1877, amount available		422,318 17
Amount (estimated) required for completion of existing project		3,582,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		500,000 00

(See Appendix F 6.)

7. *Improvement of New River, from the lead-mines in Wythe County, Virginia, to the mouth of the Greenbrier River, West Virginia.*—A survey of this portion of the New River was made in 1872. A report was printed in the annual report of the Chief of Engineers for 1873. Two estimates were submitted—one looking to an improvement to facilitate the navigation by the keel-boats now used, at a cost of $100,000; the other contemplating a 3-foot steamboat navigation, to cost $1,000,000.

The first appropriation for the work was $15,000, August 14, 1876; but it was not made available until May, 1877. As this appropriation was insufficient for a general improvement, it seemed necessary to confine what should be done at present to a limited portion of the river, and to that scheme which involved the least expense, viz, for the keel-boats now in use, it being the understanding that what is first done in the smaller improvement should be arranged with a view to its utilization and adaptation some future day, when the means provided shall suffice to enter upon the improvement of the river for light steamboats.

It seemed also expedient that the first portions of the river treated should be in the vicinity of New River bridge, in order to facilitate communication of at least a portion of the country through which the river flows with an existing outlet east and west—the Virginia and Tennessee Railroad—which is itself in connection with the whole system of rail and water intercommunication of the country.

It is expected that the work will be completed, as far as the funds available will allow, before the close of 1877.

Amount appropriated by act approved August 14, 1876	$15,000 00
July 1, 1877, amount expended during fiscal year	78 25
July 1, 1877, amount available	14,921 75
Amount (estimated) required for completion of existing project	85,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	50,000 00

(See Appendix F 7.)

8. *Improvement of the Cape Fear River, North Carolina.*—Very little could be done in this important work during the first half of the fiscal year, owing to the want of funds. An appropriation of $132,500 was made by the act of August 14, 1876, of which $110,000 became available toward the latter part of September. Proposals for stone for continuing the closing work at New Inlet were immediately invited, but it became expedient to reject those first received, and a second call was necessary. The lowest of the new bids was accepted, but the delivery of stone could not be commenced until some time in January. The contract provided for the delivery of 45,000 cubic yards. Up to June 30, over 20,000 yards had been put upon the work between Zeke's and Federal Points, bringing it up to low-water mark for about two-fifths of

its length, without, however, giving it the full width. It is expected that this work will be brought up to the level of low-water throughout its whole length by the end of 1877.

Dredging should be resumed on the Baldhead Bar, but this cannot be done until the suction-dredge shall have been repaired and some important improvements applied to her, for which funds are not now available.

The width of the channel at the "Logs," which is now 130 feet, should be increased to 250 feet. More dredging will be required at the upper end of the cut behind the Horseshoe Shoal, when the closure of New Inlet shall have enabled the direction of the portion of the cut opposite New Inlet to be more certainly defined.

There is every reason to expect a favorable conclusion to this improvement at no distant day, if sufficient funds be supplied for its proper progress.

July 1, 1876, amount available	$22, 722 72	
Amount appropriated by act approved August 14, 1876	132, 500 00	
		$155, 222 72
July 1, 1877, amount expended during fiscal year	63, 434 12	
July 1, 1877, outstanding liabilities	3, 856 35	
		67, 290 47
July 1 1877, amount available		87, 932 25
Amount (estimated) required for completion of existing project		160, 000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		160, 000 00

(See Appendix F 8.)

IMPROVEMENT OF THE HARBORS OF WASHINGTON AND GEORGETOWN, DISTRICT OF COLUMBIA; OF TRIBUTARIES OF THE LOWER POTOMAC; OF RAPPAHANNOCK, ELIZABETH, AND NANSEMOND RIVERS, VIRGINIA; OF RIVERS IN NORTH CAROLINA—IMPROVEMENT OF NORFOLK HARBOR.

Engineer in charge, S. T. Abert, United States Civil Engineer.

1. *Harbors of Washington and Georgetown, District of Columbia.*—The work of removing rocks from the harbor of Georgetown, which was in progress at the date of the last annual report, was continued until August 15, 1876, when the machinery was returned to the James River improvement. Three of the most dangerous rocks were removed, the amount of rock-excavation being 522 cubic yards.

The results of these operations will be found in detail in the Appendix.

The main ship-channel of the river, between the Virginia draw of the Long Bridge and Georgetown, has been rapidly filling up with sand and *débris* brought down by freshets. The preservation of a navigable depth through this channel is of vital importance to the Cumberland coal trade of Georgetown, in which numerous vessels are engaged, and an estimate has been prepared by the engineer in charge for dredging a channel 250 feet wide and 18 feet deep at low-water. The amount required for this purpose is $42,233.

The Washington Channel along the immediate city front, between the arsenal and the Washington draw of the Long Bridge, has become so shoal as to seriously interfere with the trade of the city. As the channel is the only one by which steamboats and shipping can reach the city wharves, it should be deepened and widened to meet the wants of navigation.

The estimate for a channel 200 feet wide and 12 feet deep at low-water is $57,640.

July 1, 1876, amount available	$9,441 87
July 1, 1877, amount expended during fiscal year	6,585 25
July 1, 1877, amount available	2,856 62
Amount (estimated) required for completion of existing project	100,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1876.	100,000 00

(See Appendix G 1.)

2. *Accotink Creek, Virginia.*—No work has been done during the year, as no funds have been available.

The amount required to complete the work according to the original estimate is $14,000.

(See Appendix G 2.)

3. *Occoquan River, Virginia.*—As no appropriation has been made for this river, no work could be done. The channel at the mouth of the river, which has been partially re-excavated, should be completed. It is estimated by the engineer in charge that $5,000 will be required for this work, and $5,000 for the construction of a dike at the bar near Occoquan.

July 1, 1876, amount available	$422 01
July 1, 1877, amount expended during fiscal year	220 00
July 1, 1877, amount available	202 01
Amount (estimated) required for completion of existing project	10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	10,000 00

(See Appendix G 3.)

4. *Aquia Creek, Virginia.*—No funds have been available for this work during the year. The estimate for its completion is, as in last annual report, $14,500.

Amount (estimated) required for completion of existing project	$14,500 00
Amount that can be profitably expended in fiscal year ending Jnue 30, 1879.	14,500 00

(See Appendix G 4.)

5. *Nomini Creek, Virginia.*—The dredging operations were resumed August 16, 1876, and suspended September 5, when the funds were exhausted. The channel was found to be in good condition, but should be further widened, as, owing to its exposed position, it is subject to deposits of sand from the action of the tidal currents and winds.

The improvement has been of much value to the trade of the adjacent country.

July 1, 1876, amount available	$1,853 23
July 1, 1877, amount expended during fiscal year	1,853 23
Amount (estimated) required for completion of existing project	7,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1879..	7,500 00

(See Appendix G 5.)

6. *Rappahannock River, Virginia.*—The dredging operations at Fredericksburg have been continued under the appropriation of $10,000 made August 14, 1876, and a dike has been constructed on the right bank of the river below the steamboat wharf.

Owing to the continued deposits from freshets an annual appropriation of $7,500 will, in the opinion of the engineer in charge, be required

for dredging, and during the next year $8,000 for building a dike for the deposit of the dredged material, as the present dikes are full.

July 1, 1876, amount available	$400 75	
Amount appropriated by act approved August 14, 1876	10,000 00	
		$10,400 75
July 1, 1877, amount expended during fiscal year	7,481 74	
July 1, 1877, outstanding liabilities	631 62	
		8,113 36
July 1, 1877, amount available		2,287 39
Amount (estimated) required for completion of existing project		59,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		15,500 00

(See Appendix G 6.)

7. *Elizabeth River, Virginia.*—The contract for the work under the appropriation of $5,000 made by the act of August 14, 1876, has been awarded. The work proposed is widening the "gap" about one mile below the lock of the Albemarle and Chesapeake Canal and dredging a "cut-off" near the lock to facilitate the entrance of vessels.

Some further dredging is required to meet the wants of navigation, for which an appropriation of $5,000 is recommended.

July 1, 1876, amount available	$118 02
Amount appropriated by act approved August 14, 1876	5,000 00
	5,118 02
July 1, 1877, amount expended during fiscal year	128 13
July 1, 1877, amount available	4,989 89
Amount (estimated) required for completion of existing project	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	5,000 00

(See Appendix G 7.)

8. *Norfolk Harbor, Virginia.*—An appropriation of $35,000 was made in the river and harbor act of August 14, 1876, for the improvement of this harbor, the work proposed being dredging a channel through the bar at the mouth of the southern branch of Elizabeth River. For the continuation of this work and for the removal of wrecks $25,000 are asked by the engineer in charge.

Amount appropriated by act approved August 14, 1876	$35,000 00
July 1, 1877, amount expended during fiscal year	289 15
July 1, 1877, amount available	34,710 85
Amount (estimated) required for completion of existing project	25,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	25,000 00

(See Appendix G 8.)

9. *Nansemond River, Virginia.*—The appropriation of $5,000, made August 14, 1876, will be expended in widening the channel at Suffolk, dredging a channel through Shingle Creek Bar, a short distance below Suffolk, and repairing a part of the old dike at Western Branch Bar. For the completion of the work $2,000 will be needed.

July 1, 1876, amount available	$87 59
Amount appropriated by act approved August 14, 1876	5,000 00
	5,087 59
July 1, 1877, amount expended during fiscal year	347 07
July 1, 1877, amount available	4,740 52
Amount (estimated) required for completion of existing project	2,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	2,000 00

(See Appendix G 9.)

10. *Pamplico River, North Carolina.*—An appropriation of $15,000 for the improvement of this river was made by the river and harbor act of August 14, 1876, and the work is now under contract.

The operations proposed are, dredging near the town of Washington, and the removal of pile obstructions at Hill's Point, about 6 miles below Washington.

Owing to the advantageous prices at which the work was let, the present appropriation will be sufficient for the proposed improvement.

Amount appropriated by act approved August 14, 1876	$15,000 00
July 1, 1877, amount expended during fiscal year	363 96
July 1, 1877, amount available	14,636 04

(See Appendix G 10.)

11. *Roanoke River, North Carolina.*—The improvement of this river has been discontinued for want of funds. The operations of the year were seriously delayed by freshets and the sickness of the contractor's men, the river being very unhealthy.

If the work of removing snags is resumed, the engineer in charge estimates that $4,000 will be needed. The trade of the river does not seem to warrant its present improvement, as at first proposed.

July 1, 1876, amount available	$5,282 63
July 1, 1877, amount expended during fiscal year	5,100 65
July 1, 1877, amount available	181 98
Amount (estimated) required for completion of existing project	222,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	4,000 00

(See Appendix G 11.)

12. *Perquimans River, North Carolina.*—The snag-boats and machinery heretofore employed on the Roanoke River have been transferred to this river, and the stumps, &c., obstructing the channel are now being removed by hired labor, this method being more economical than by contract.

No further appropriation will be required.

Amount appropriated by act approved August 14, 1876	$2,500 00
July 1, 1877, amount expended during fiscal year	345 86
July 1, 1877, amount available	2,154 14

(See Appendix G 12.)

13. *French Broad River, North Carolina.*—In the river and harbor act approved August 14, 1876, an appropriation of $10,000 was made for this river. As no instrumental survey of the river has ever been made, such a survey has been authorized in order to obtain the data necessary for preparing a detailed project and estimate for the improvement.

Amount appropriated by act approved August 14, 1876	$10,000 00
July 1, 1877, amount available	10,000 00

(See Appendix G 13.)

IMPROVEMENT OF THE RIVERS AND HARBORS ON THE COAST OF SOUTH CAROLINA, GEORGIA, AND THE ATLANTIC COAST OF FLORIDA.

Officer in charge, Lieut. Col. Q. A. Gillmore, Corps of Engineers, having under his immediate orders Capt. James C. Post, Corps of Engineers.

1. *Improvement of Charleston Harbor, South Carolina.*—The operations during the last fiscal year have been confined to the Beach Channel

entrance, along the Sullivan's Island shore. It was found last fall that the channel had unexpectedly shoaled in the western portion of it to 5.1 feet mean low-water. To remedy this, and, if possible, secure at least the former depth of 13 feet by the natural scour resulting from an increased flow of water, it was determined to lower the height of Bowman jetty to mean low-water for some distance for the outer end. In the execution of this work, 185 linear feet have been lowered to mean low-water and 205 linear feet to 2 feet above mean low-water. The result, as ascertained by soundings taken June 25, has been a deepening of the shoal part of the channel to 14 feet mean low-water. The work upon the jetty has been suspended for the present, pending a detailed survey of the channel which has been ordered.

The United States dredging-steamer Henry Burden removed 680 cubic yards of material from the channel last autumn; but her work there was suspended in consequence of the shoaling above referred to, and has not yet been renewed.

It is proposed to expend the balance of the existing appropriation either in dredging in Beach Channel or in lowering an additional portion of the jetty to low-water level, or by dividing it between these two works, as shall be deemed most expedient after the completion of the survey.

In consequence of peculiar and necessarily unforeseen causes, which are explained in the report of the engineer in charge, the sum thus far expended in the improvement of Charleston Harbor has exceeded the original estimate by nearly 12 per cent. Another small appropriation will, it is hoped, suffice.

July 1, 1876, amount available	$1,008 80	
Amount appropriated by act approved August 14, 1876	10,000 00	
		$11,008 80
July 1, 1877, amount expended during fiscal year	3,640 09	
July 1, 1877, outstanding liabilities	1,306 64	
		4,946 73
July 1, 1877, amount available		6,062 07
Amount (estimated) required for completion of existing project		11,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		5,000 00

(See Appendix H 1.)

2. *Improvement of Savannah River and Harbor, Georgia.*—During the last fiscal year work has been carried on in five localities, as follows:

1. On the temporary dam at Cross Tides work was resumed March 6, it having been stopped the previous May by an injunction from the Supreme Court of the United States. It was found to have been impaired and weakened to some extent during the suspension of operations. On the 22d of April, a freshet, bringing with it a large quantity of drift material, destroyed 186 linear feet of the unfinished portion nearest mid-channel. It was deemed best not to resume work upon it, beyond what was necessary to secure it from further damage, until an additional appropriation was made, so that the work of enlarging the water-way below the Cross Tides, to provide for the free flow of the increased volume of water which the finished dam would divert into Front River could be carried on simultaneously with the work upon the dam.

2. In order to aid the ebb-flow into Front River and relieve the pressure on the dam, the water-way between King's and Hutchinson's Islands was enlarged by making a cut 60 feet wide and 9 feet deep. In doing this, 25,047 cubic yards of material were removed by dredging.

3. From the new channel along the Georgia shore, near "The Wrecks," 115,189 cubic yards of material were removed by dredging. In doing this, one through-cut 5,879 feet long, 24 feet wide, and 15 feet deep at mean low-water was completed, and two other cuts were under way at the close of the fiscal year. The through-cut, by flowing in from the sides, was widened to 60 feet and shoaled to 12 feet, mean low-water. A crib-work obstruction was removed from the south side of this channel. Under existing agreements, with the funds available, it is expected that a channel 120 feet wide and 13 feet deep, mean low-water, giving nearly 20 feet at ordinary high-water, will be secured by the commencement of the coming cotton-shipping season.

4. Southwest of the Oyster Bed light, 12,012 cubic yards of materials were removed by dredging, increasing the width of the channel at that point to 400 feet between the 13-foot curves. The shoaling at this point is attributed to a wreck or part of wreck which lies buried in the sand.

5. In the dredged channel, northeast of Fort Pulaski, the shoaling mentioned in the last annual report has continued, due, perhaps, to the obstruction near the Oyster Bed light mentioned above. Six thousand three hundred and ninety-five cubic yards of materials were removed by dredging, which deepened the channel to 12¾ feet, mean low-water. Shoaling to some extent has taken place in other parts of the river where dredging was previously done, but not enough to require dredging. The balance of the existing appropriation will be expended in dredging in the new channel along the south shore of the river near "The Wrecks."

The work recommended to be done during the next fiscal year, and for which an appropriation is requested, is as follows:

A. To finish the dam at Cross Tides.

B. To increase the area of water-way at contracted points below Cross Tides, so as to allow a free flow of the increased volume of water expected to be secured by the dam.

C. To remove a portion of the outer end of the old jetty at King's Island, which now acts as an obstruction.

D. To continue the dredging in the new channel, at "The Wrecks," to a mean low-water depth of 14½ feet, and to a suitable width.

E. To remove the wreck or portion of wreck near Oyster Bed light, and perhaps do some dredging at that point.

F. To restore the originally dredged depth of 14½ feet, mean low-water, to the channel northeast of Fort Pulaski, if necessary.

G. To dredge at other points, if found to be necessary.

July 1, 1876, amount available	$3,771 81	
Amount appropriated by act approved August 14, 1876	62,000 00	
		$65,771 81
July 1, 1877, amount expended during fiscal year	28,634 49	
July 1, 1877, outstanding liabilities	9,285 17	
		37,919 66
July 1, 1877, amount available		27,852 15
Amount (estimated) required for completion of existing project		299,320 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		150,000 00

(See Appendix H 2.)

3. *Improvement of inside passage between the Saint John's River and Fernandina, Florida.*—No work was done upon this passage during the last fiscal year for want of funds. The channel, 40 feet wide and 4 feet deep, opened through the shoals during the fiscal year ending June 30, 1876, was examined during the past month, so far as an examination

could be made while passing through it on a steamer. It was found that shoaling had taken place to some extent in Gunnison's Cut, and also at the confluence of Sister's Creek with the Saint John's River. Two weekly freight lines between Fernandina and the Saint John's River now use this passage, and it is deemed important to provide for its enlargement.

Amount (estimated) required for completion of existing project..$160,000 to $370,000
Amount that can be profitably expended in fiscal year ending June 30, 1879.. 25,000

(See Appendix H 3.)

4. *Saint Augustine Creek, (Thunderbolt River,) Georgia.*—This river constitutes part of the inside passage between the Savannah River and Wassaw Sound, and is used by small freight and passenger steamers plying between Savannah and Brunswick, Darien, Fernandina, and the Saint John's River.

The only improvement that is recommended is the removal of a single dangerous obstruction, consisting of a large timber dry-dock sunk there during the civil war, which lies directly in the channel.

No appropriation was ever made by Congress for the improvement of this stream.

Appropriation recommended for this purpose $5,000 00

(See Appendix H 4.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

In reply to a resolution of the Senate of January 9, 1877, directing the Secretary of War "to communicate to the Senate all information in his possession concerning a *water-line of transportation from the mouth of the Saint Mary's River, between the States of Georgia and Florida, through Okefenokee Swamp, and through the State of Florida to some suitable point on the Gulf of Mexico*, embracing the probable nature and character of such a water-line, and the extent of country and population to be benefited by its construction, and an estimate of the cost of the necessary surveys or examinations therefor," a report from Lieut. Col. Q. A. Gillmore, Corps of Engineers, to whom the resolution was referred, was transmitted to the Senate at its last session, and printed as Senate Ex. Doc. No. 22, 44th Congress, 2d session.

(See Appendix H 6.)

GULF OF MEXICO.

IMPROVEMENT OF THE HARBORS OF MOBILE, ALABAMA, AND OF PENSACOLA AND CEDAR KEYS, FLORIDA—IMPROVEMENT OF THE NAVIGATION OF CHOCTAWHATCHEE, APALACHICOLA, CHATTAHOOCHEE, AND FLINT RIVERS.

Officer in charge, Capt. A. N. Damrell, Corps of Engineers.

1. *Improvement of harbor at Mobile, Alabama.*—This work has been completed in accordance with adopted plan. A channel has been cut through Dog River Bar 200 feet wide and 13 feet deep, and through Choctaw Pass 300 feet wide and 13 feet deep at mean low-water. The estimated cost in 1870 was $656,800; as revised later in the same year, with some modifications in plan, $774,315.52; as revised in 1873, with some further modifications, $589,237.19. The actual cost, including $70,550 expended by the Alabama State harbor board, is $460,719.55.

Reduction in cost below estimates is due to successive declines in con-

tract-prices for dredging under the different appropriations below earlier and estimated prices.

The officer in charge considers a new plan of improvement, demanded by the commercial necessities of the port of Mobile, whereby all vessels crossing the outer bar, which has 21 feet of water on it at mean low-tide, may pass up to the wharves of the city, and recommends an appropriation of $10,000 to be used in making the necessary surveys for determining, if the project is feasible, and the best plan, and commencing the work after these matters are properly determined. Appropriation asked by the officer in charge for fiscal year ending June 30, 1879, $10,000.

July 1, 1876, amount available	$16,265 83
July 1, 1877, amount expended during fiscal year	12,250 26
July 1, 1877, amount available	4,015 57

(See Appendix I 1.)

2. *Removal of obstructions at the entrance to the harbor of Pensacola, Florida.*—The attention of this office has been called to the importance of an examination to ascertain the cost of removing certain wrecks near the entrance to Pensacola Harbor, which at present endanger the passage of the larger class of vessels entering that port.

The officer in charge of improvements in that section estimates the cost of such examination at $1,500, and the probable cost of removing the obstructions at $20,000.

(See Appendix I 2.)

3. *Improvement of the harbor of Cedar Keys, Florida.*—Nothing was done on this work during the year for want of funds. A contract for dredging, in continuation of the improvement, was made June 1, 1877. Under this contract the work will be continued during the next fiscal year, as far as the appropriation of $10,000 of August 14, 1876, will allow.

Appropriation asked by the officer in charge for the fiscal year ending June 30, 1879, $50,000.

July 1, 1876, amount available	$4 95
Amount appropriated by act approved August 14, 1876	10,000 00
	10,004 95
July 1, 1877, amount expended during fiscal year	21 30
July 1, 1877, amount available	9,983 65
Amount (estimated) required for completion of existing project	101,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	50,000 00

(See Appendix I 3.)

4. *Improvement of Choctawhatchee River, Alabama and Florida.*—Work on the improvement of this river was carried on during part of the month of May and the whole of June. It consisted in the removal of snags and sunken logs and overhanging trees. Seventy-five miles of the lower part of the river have been kept in fair boating condition.

After the present season's work there will remain, to complete the improvement, the cutting of a channel through Half-Moon Bluff Shoal, about 130 miles from the mouth, and another about 4 miles below Geneva, each from 200 to 300 feet long, composed of large blocks of limestone, and the removal of three wrecks and such snags as may accumu-

late after the cessation of work, for which the officer in charge asks for the fiscal year ending June 30, 1879, $19,000.

July 1, 1876, amount available	$284 93
Amount appropriated by act approved August 14, 1876	5,000 00
	5,284 93
July 1, 1877, amount expended during fiscal year	2,498 55
July 1, 1877, amount available	2,786 38
Amount (estimated) required for completion of existing project	19,332 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	19,000 00

(See Appendix I 4.)

5. *Improvement of Appalachicola River, Florida.*—Work was prosecuted on this river during December, 1876, and January, 1877, and consisted in the removal of a large raft at the lower end, and of several large stumps at the upper end of Moccasin Slough.

It is intended, during the next year, to enlarge and straighten the channel through the slough and at its two ends, in order to prevent the successive accumulation of rafts which now occur.

The greater portion of this work was not anticipated last year, but its necessity has since been shown.

An appropriation of $20,000 is asked for by the officer in charge for the fiscal year ending June 30, 1879.

July 1, 1876, amount available	$8,555 50
July 1, 1877, amount expended during fiscal year	3,778 59
July 1, 1877, amount available	4,776 91
Amount (estimated) required for completion of existing project	60,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	20,000 00

(See Appendix I 5.)

6. *Improvement of Chattahoochee and Flint Rivers, Georgia.*—This work was continued during the year as follows: A large number of snags and overhanging trees were removed; the head of the jetty at Wolfax Bar was protected by rock riprap; the breakwater on the Georgia side at the same bar was extended 560 feet down. A channel 60 feet wide and 4 feet deep was made through Little Uchee Shoal, by blasting. A channel 55 feet wide and 3 feet deep was obtained through Slick Bluff Shoals by the same means, and the Middle Rock, a little below, was partially removed.

Extensive repairs were made to the steam snag-boat Clara Dunning, and minor repairs were made on the blasting-boat and tender.

It is proposed during next year to complete the work at Slick Bluff and Middle Rock, and then to continue work on the worst bars on the Chattahoochee River, as Hardridge's Shoals and King's Rock.

An appropriation of $50,000 is asked for by the officer in charge for the fiscal year ending June 30, 1879.

July 1, 1876, amount available	$27,603 06
Amount appropriated by act approved August 14, 1876	20,000 00
	47,603 06
July 1, 1877, amount expended during fiscal year	22,037 97
July 1, 1877, amount available	25,565 09
Amount (estimated) required for completion of existing project	260,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	50,000 00

(See Appendix I 6.)

7. *Improvement of Black Warrior and Tombigbee Rivers, Alabama.*—Operations were continued on this improvement principally below the point to which the work had been previously carried.

The working season was reduced by various causes to about six months. During that time twelve bars were improved by the construction of 5,076 linear feet of jetties and the removal of 688 snags. The whole number of snags removed was 798.

A great improvement has been effected, but a portion still remains to be opened before the full benefit of the work already done can be had.

July 1, 1876, amount available	$5,118 08
Amount appropriated by act approved August 14, 1876	15,000 00
	20,118 08
July 1, 1877, amount expended during fiscal year	14,655 04
July 1, 1877, amount available	5,463 04

Amount (estimated) required for completion of existing project	132,603 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	100,000 00

(See Appendix I 7.)

IMPROVEMENT OF THE MOUTH OF THE MISSISSIPPI RIVER; OF THE ENTRANCE TO GALVESTON HARBOR; OF SABINE PASS; OF THE SHIP-CHANNEL IN GALVESTON BAY; AND OF PASS CAVALLO, INLET TO MATAGORDA BAY, TEXAS.

Officer in charge, Capt. C. W. Howell, Corps of Engineers, having under his immediate orders Lieut. C. E. L. B. Davis, Corps of Engineers.

1. *Improvement of the mouth of the Mississippi River at Southwest Pass.*—The work of improvement at the Southwest Pass, by dredging, was continued as heretofore, and with favorable results.

The channel has been maintained at a quite uniform depth, and while vessels have suffered detention, mainly from improper handling, there has been none such as marked the early years of the work.

The large number of deep-draught vessels using the dredged channel during the past year, together with the large amount of cotton and grain carried by them, partially indicate the benefits commerce has derived from the work, without which it is thought commerce must have sustained serious loss from lack of reliable outlet to the sea.

During the year, surveys, current-measurements, and observations for material carried in suspension and for volume of discharge have been made in the river and its various passes, the arrangement, comparison, and compilation of which are not yet completed. Should dredging be continued throughout the present fiscal year, the dredge-boats belonging to the work will require extensive repairs. Therefore, although means are provided for work during the first one-third of the year, the amount found to be an average of several years' expenses is resubmitted as the estimate for the year.

The detailed report of the officer in charge, who has made the subject of an improved outlet to the Mississippi River a study for over eight years, presents facts and conclusions of interest, to which attention is invited.

Whole amount appropriated		$1,327,224 38
Whole amount expended		1,310,539 63
July 1, 1876, amount available	$22,894 04	
Amount appropriated by act approved August 14, 1876	100,000 00	
		122,894 04
July 1, 1877, amount expended during fiscal year	106,209 49	
July 1, 1877, outstanding liabilities	5,923 77	
		112,133 26
July 1, 1877, amount available		10,760 78
Amount that can be profitably expended in fiscal year ending June 30, 1879		150,000 00

(See Appendix J 1.)

2. *Improvement of entrance to Galveston Harbor, Texas.*—Owing to retention of appropriation for this work, its prosecution toward completion has been greatly retarded during the year. From this cause operations were suspended early in July, 1876, and not resumed until the middle of September, when a small portion of the appropriation was made available. But the most favorable season for construction of the gabionade had passed away during suspension, and upon resumption of the work operations were confined to the collection of material, its manufacture into gabions, mats, &c., &c., required in the work of construction, the procurement of machinery, and the repair and improvement of plant, and completion of buildings required on the work.

In January, the allotment from the appropriation for the work being exhausted, operations were again suspended. Upon release of the balance of the appropriation, in February, work was resumed and continued throughout the year.

Work of construction was also delayed by unusually stormy weather during the spring and early summer.

During the year Fort Point gabionade was extended 1,000 feet. The effect of that structure has been to maintain a depth of water over the bar at mean low-tide of from 15¾ feet in September, 1876, to 16¾ feet in May, 1877, with increasing improvement, as shown by the report for June.

This improvement it is expected will be accelerated upon completion of repairs to the Fort Point breakwater, a large portion of which was destroyed by the storm of September, 1875. This work has been delayed in consequence of the difficulty experienced in procuring suitable piles and the obstructions met with in placing them in the breakwater.

Work of construction on the Bolivar Point gabionade has consisted in placing piling which is to run out to water deep enough to sink gabions and in constructing 172 feet of gabionade.

It is proposed to continue construction at this point until a depth of channel over the outer bar is obtained equal to that over the inner bar.

The officer in charge reports that, in consequence of additions to strengthen the gabions, the cost of their manufacture has been increased, as also has the cost of construction, beyond his original estimate.

The estimate of cost of manufacture was based upon experimental work ordered for that purpose before the work at Galveston was commenced.

The placing of mats underneath, at the sides, and in front of the gabions (not contemplated in original estimate) has increased the cost of construction, but it is thought that the saving in settlement from their use will obviate the necessity for several rows of gabions, as was at first designed, and that two rows, at most, will answer instead.

The effects produced by the work on the inner bar lead to the belief that the gabionade at Bolivar Point need not be extended as far as was designed to produce the result desired.

Should the above saving in construction be realized, it may balance its increased cost and the increased cost of manufacture, and thus permit the completion of the work with the amount provided for in the revised estimate.

To provide against possible suspensions in future, and consequent increased cost of the work, it is recommended that the balance of the estimate for its completion be made available during the next session of Congress.

Original estimate		$1,259,446 43
Revised estimate		559,740 00
Whole amount appropriated		352,000 00
Whole amount expended		307,935 47
July 1, 1876, amount available	$18,749 98	
Amount appropriated by act approved August 14, 1876	142,000 00	
		160,749 98
July 1, 1877, amount expended during fiscal year	116,685 45	
July 1, 1877, outstanding liabilities	8,011 93	
		124,697 38
July 1, 1877, amount available		36,052 60
Amount (estimated) required for completion of existing project		207,740 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		150,000 00

(See Appendix J 2.)

3. *Continuation of the work on the ship-channel in Galveston Bay, between Red Fish Bar and Morgan's Point.*—Congress, by act approved August 14, 1876, appropriated $72,000 for this work, which amount was made available April 25, 1877.

In section 2 of the above-mentioned act Congress also directed that a "survey for a ship-channel through Galveston Bay, beginning at 12 feet water in the mouth of the San Jacinto River and running out of the mouth of said river east of Morgan's Point to the present channel through Red-Fish Bar, thence through the same, extending through Galveston Harbor, passing west of Half-Moon Shoals and Pelican Island, and to 12 feet water in Galveston Channel; and to cause an estimate of the cost of the same to be made, and of the comparative merits of the same, with the route to the head of Bolivar channel, and of the effects of the completion of each of said channels on the Galveston Harbor as to shoaling or deepening the same." * * * *

As the selection of a line through Galveston Bay upon which to commence work with the appropriation available before the survey was completed would have anticipated the decision of Congress upon the results of the survey, it was recommended that decision upon which line the appropriation for continuing the work on the ship-channel should be expended be deferred until the final report upon the survey was made and the future action of Congress thereon was known.

This recommendation (see Appendix J 3) was approved by the Secretary of War.

The survey is now completed, and the report thereon is submitted herewith, together with the report of a board of engineer officers convened for the purpose of considering the question of location of the proposed channel.

Whole amount appropriated	$97,000 00
Whole amount expended	25,000 00
Amount appropriated by act approved August 14, 1876	72,000 00
July 1, 1877, amount available	72,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	150,000 00

(See Appendix J 3.)

4. *Survey for a ship-channel through Galveston Bay, Texas.*—This survey was ordered by act of Congress approved August 14, 1876, for the purpose of ascertaining the comparative merits of the different routes through Galveston Bay, described in section 2 of the above act, and "the effects of the completion of each of said channels on the Galveston Harbor as to shoaling or deepening the same."

The survey has been completed, and the report thereon is submitted herewith.

Amount appropriated by act approved August 14, 1876	$10,000 00
July 1, 1877, amount expended during fiscal year	8,589 64
July 1, 1877, amount available	1,410 36

(See Appendix J 4.)

5. *Improving Sabine Pass, Texas.*—The contractors for this work under the appropriation approved March 3, 1875, abandoned their contract, (during the year,) which has been annulled, and under an appropriation of $38,000 for the work, approved August 14, 1876, together with the balance of appropriation for 1875, proposals for the work of dredging have been invited by advertisement.

Original estimated cost		$87,513 90
Whole amount appropriated		58,000 00
Whole amount expended		6,225 58
Revised estimate for a 15-foot channel		176,071 00
Balance required to complete a 15-foot channel		118,071 00
Revised estimate for a 20-foot channel		390,317 00
Balance required to complete a 20-foot channel		332,317 00
July 1, 1876, amount available	$16,658 84	
Amount appropriated by act approved August 14, 1876	38,000 00	
		54,658 84
July 1, 1877, amount expended during fiscal year	2,884 42	
July 1, 1877, outstanding liabilities	1,285 00	
		4,169 42
July 1, 1877, amount available		50,489 42
Amount (estimated) required for completion of existing project for 12-foot channel		47,026 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		47,026 00

(See Appendix J 5.)

6. *Improvement to Pass Cavallo, inlet to Matagorda Bay, Texas.*—By act of Congress, approved August 14, 1876, $20,000 was appropriated for this work.

As this amount is inadequate for even a commencement of the work without imminent risk of serious loss, it was recommended by me (see Appendix J 6) that expenditure of the appropriation be suspended to await the future action of Congress, which recommendation was approved by the Secretary of War.

Amount appropriated by act approved August 14, 1876	$20,000 00
July 1, 1877, amount available	20,000 00
Amount (estimated) required for completion of existing project	695,325 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	130,000 00

(See Appendix J 6.)

PROTECTION OF THE RIVER-BANKS AT FORT BROWN, TEXAS, FROM ENCROACHMENT OF THE RIO GRANDE.

Officer in charge, Capt. James F. Gregory, Corps of Engineers.

The act making appropriations for the sundry civil expenses of the Government for the fiscal year ending June 30, 1877, contained an ap-

propriation of $10,000 for a work necessary for this purpose, to be expended under the direction of the Secretary of War.

In accordance therewith, a pile jetty or breakwater has been built for the protection of about 500 feet of the river-front near the northwest corner of the post.

The work is designed to arrest the progress of encroachment which threatens not only to destroy some of the most valuable buildings at the post, but to break through into the lagoon, which would entirely change the channel of the river, and leave the greater part of the post on the opposite side of its channel.

No further recommendation with reference to protection can be made until the effect of the next high water shall be seen upon the work, and the banks immediately above and below it.

Amount appropriated by act approved July 31, 1876, making appropriations for sundry civil expenses of the Government for the fiscal year ending June 30, 1877, &c.	$10,000 00
July 1, 1877, amount expended during fiscal year	7,197 59
July 1, 1877, amount available	2,802 41

(See Appendix K.)

WESTERN RIVERS.

IMPROVEMENT OF OUACHITA AND YAZOO RIVERS—REMOVAL OF RED RIVER RAFT—IMPROVEMENT OF TONE'S AND CYPRESS BAYOUS, RED RIVER—SURVEY FOR THE PRESERVATION OF THE PORT OF MEMPHIS—WATER-GAUGES ON THE MISSISSIPPI AND ITS PRINCIPAL TRIBUTARIES.

Officer in charge, Capt. W. H. H. Benyaurd, Corps of Engineers.

1. *Improvement of the Ouachita River, Arkansas and Louisiana.*—Upon the appropriation of August 14, 1876, becoming available, May 1, 1877, work was commenced on the dams at Spoon Camp Shoals and Buffalo Flats for the purpose of concentrating the water in a single channel when at a low stage.

At the end of June the dam at Spoon Camp Shoals was finished and work commenced upon that at Buffalo Flats.

During the coming season it is proposed to finish this dam and operate with the snag-boat in removing obstructions in the river.

July 1, 1876, amount available	$358 03
Amount appropriated by act approved August 14, 1876	12,000 00
	12,358 03
July 1, 1877, amount expended during fiscal year	5,527 47
July 1, 1877, amount available	6,830 56
Amount that can be profitably expended in fiscal year ending June 30, 1879.	20,000 00

(See Appendix L 1.)

2. *Improvement of the Yazoo River, Mississippi.*—No work was done during the past fiscal year for want of funds.

As the appropriation is too small to admit of the purchase of an outfit expressly for this river, so soon as the snag-boat O. G. Wagner can be spared from the Ouachita River it is proposed to continue the work of removing the wrecks, snags, and other obstructions in this river.

Amount appropriated by act approved August 14, 1876	$15,000 00
July 1, 1877, amount expended during fiscal year	1,043 49
July 1, 1877, amount available	13,956 51
Amount (estimated) required for completion of existing project	93,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	50,000 00

(See Appendix L 2.)

3. *Removing Raft in Red River and closing Tone's Bayou, Louisiana.—Removing Raft in Red River.*—Operations were continued at intervals during the season with the steamer Thos. B. Florence, and one crane-boat, with full working force, in removing jams and drift-piles and preventing a blockade of the river and re-formation of the raft.

During the coming season it is proposed to remove portions of the old raft still remaining, so as to make a channel at least 150 feet wide through the entire length of the raft, to cut timber along the banks, and to pull out the most dangerous snags.

Closing Tone's Bayou.—A low-water dam was put in the bayou, (high water coming on prevented it being built higher,) and so far it has successfully withstood the flood, though some caving has taken place in the left bank below.

During the coming season it is proposed to protect the banks for some distance below the dam, and also finish off the top.

As the river below cuts out each season, additions should be made to the height of the dam until the entire closure be effected.

July 1, 1876, amount available for removing raft	$207 15	
Amount appropriated by act approved August 14, 1876	35,000 00	
		$35,207 15
July 1, 1877, amount expended during fiscal year on raft work.	6,393 06	
July 1, 1877, amount expended during fiscal year on Tone's Bayou	26,551 77	
		32,944 83
July 1, 1877, amount available		2,262 32
Amount (estimated) required for completion of existing project for raft-work		140,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879, for raft-work		50,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879, on Tone's Bayou		10,000 00

(See Appendix L 3.)

4. *Continuing the work of dredging and removing obstructions to navigation in Cypress Bayou, Texas.*—No work was done on the bayou the past season. The building of a new dredge-boat was commenced and is now in progress.

During the coming season it is proposed to finish the dredge-boat and have her operate in the work of straightening and dredging the channel from Jefferson to the mouth of the bayou.

July 1, 1876, amount available	$22 10
Amount appropriated by act approved August 14, 1876	13,000 00
	13,022 10
July 1, 1877, amount expended during fiscal year	3,121 37
July 1, 1877, amount available	9,900 73
Amount that can be profitably expended in fiscal year ending June 30, 1879.	20,000 00

(See Appendix L 4.)

5. *Protection of the water-front of the port of Memphis, Tennessee.*—In consequence of a memorial from the city councils of Memphis, representing the urgent necessity of ascertaining what measures should be taken for the protection of the landings of the city from further injury from the action of the current of the Mississippi, an examination of the locality was made, with the approval of the Secretary of War, and a report submitted to this office in February last, proposing a plan, with estimates of cost, for the protection of the water-front.

The officer in charge recommends protecting the caving bank with a covering of brush mattresses or rafts loaded with stone. The average width of this covering would be 175 feet, and the length of shore-line to be protected about 7,600 feet. He divides the space to be protected into two parts, that below Wolf River, 5,600 feet long, which is the most important and requiring immediate attention, and that above Wolf River, about 2,000 feet, which, while needing protection, is not of such immediate importance, and he submits estimates of the cost of the work as follows:

Below Wolf River	$126,000 00
Above Wolf River	44,000 00
	170,000 00

The work, when commenced, should, from its nature, be continuous. (See Appendix L 5.)

6. *Water-gauges on the Mississippi River and its principal tributaries.*—Observations were continued at all the gauges. A new gauge was put in at Memphis, and repairs made to such of the others as required them.

July 1, 1876, amount available	$1,537 26
Amount appropriated by act approved August 14, 1876	5,000 00
	6,537 26
July 1, 1877, amount expended during fiscal year	4,869 02
July 1, 1877, amount available	1,668 24
Amount that can be profitably expended in fiscal year ending June 30, 1879.	5,000 00

(See Appendix L 6.)

REMOVING SNAGS AND WRECKS FROM MISSISSIPPI, MISSOURI, AND ARKANSAS RIVERS, AND FROM WHITE AND SAINT FRANCIS RIVERS—IMPROVEMENT OF MISSOURI RIVER AT SAINT JOSEPH AND NEBRASKA CITY, AND OF ARKANSAS RIVER AT FORT SMITH—IMPROVEMENT OF WHITE RIVER ABOVE JACKSONPORT—SURVEYS ON MISSOURI RIVER.

Officer in charge, Maj. Charles R. Suter, Corps of Engineers.

1. *Removing snags from Mississippi, Missouri, and Arkansas Rivers.*—During the past season the expenditures on this work were limited to $50,000. The snag-boats worked on the Mississippi from Saint Louis to Vicksburg, 834 miles; in the Missouri, from the mouth to Boonville, 195 miles; and on the Arkansas, from the mouth to Silver Lake, 65 miles.

Owing to the late date at which the appropriation became available, this work could not be commenced until the middle of October, and operations were much impeded by the heavy ice of the winter months.

During the coming season no field operations are contemplated, the only balance available being barely sufficient to care for the boats and other Government property until a new appropriation is made.

The officer in charge renews his recommendation that sufficient money be appropriated to enable him to replace with iron the wornout hulls of the wooden snag-boats. Until this is done, the work cannot be made as efficient as the needs of commerce demand.

The sum appropriated for the annual expense of operating the boats should also, in his opinion, be increased.

July 1, 1876, amount available	$4,358 98
Amount allotted from appropriation for improvement of the Mississippi, Missouri, and Arkansas Rivers, by act approved August 14, 1876	60,000 00
	64,358 98
July 1, 1876, amount expended during fiscal year	55,184 19
July 1, 1876, amount available	9,174 79

Amount required for the fiscal year ending June 30, 1879, viz:

For building one large iron-hulled snag-boat, to carry machinery of one of the present wooden boats	$140,000 00
For building one small iron-hulled snag-boat, to carry machinery of one of the present wooden boats	105,000 00
For building one small iron-hulled stern-wheel snag-boat	60,000 00
For repairing one wooden snag-boat, and fitting it up for wrecking purposes	50,000 00
For working expenses of 5 boats, 10 months each, at $4,000 per month	200,000 00
	555,000 00

(See Appendix M 1.)

2. *Removing snags and wrecks from White and Saint Francis Rivers.*—No appropriation has been made for work on these streams for several years; but, as it is of great necessity, the officer in charge submits an estimate for a snag-boat and expense of operating the same.

Amount required for fiscal year ending June 30, 1879, viz:

For building one stern-wheel iron snag-boat	$60,000 00
For operating same 10 months, at $4,000 per month	40,000 00
	100,000 00

(See Appendix M 2.)

3. *Improving Missouri River opposite Saint Joseph.*—The object of this improvement is to stop the erosion of the Kansas shore opposite the city of Saint Joseph, Mo., which, if allowed to go on unchecked, threatens to cut off a narrow neck or peninsula, taking the river away from the city and seriously endangering the railroad bridge across the Missouri River at that point.

An allotment of $10,000 was made for this work from the appropriation for the improvement of Mississippi, Missouri, and Arkansas Rivers, and will be expended during the coming season in extending and strengthening the works already erected by the bridge company to retain the channel of the river in its present position.

Amount allotted from appropriation for improvement of the Mississippi, Missouri, and Arkansas Rivers, by act approved August 14, 1876,	$10,000 00
July 1, 1877, amount expended during fiscal year	901 19
July 1, 1877, amount available	9,098 81
Amount (estimated) required for completion of existing project	140,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	80,000 00

(See Appendix M 3.)

4. *Improvement of the Missouri River at Nebraska City, Nebraska.*—An allotment of $15,000 was made from the appropriation for improvement

of the Mississippi, Missouri, and Arkansas Rivers for work at this locality, and a survey having been made, the officer in charge submitted a report on the subject, with plan and estimates.

The object of the work is to check an injurious change in the river channel, which has nearly destroyed the water-front of Nebraska City, besides greatly damaging other property in the neighborhood.

The sum allotted will all be expended during the coming season, leaving the completion of the work to be provided for by future appropriations.

Amount allotted from appropriation for improvement of the Mississippi, Missouri, and Arkansas Rivers, by act approved August 14, 1876	$15,000 00
July 1, 1877, amount expended during fiscal year	3,229 43
July 1, 1877, amount available	11,770 57
Amount (estimated) required for completion of existing project	135,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	75,000 00

(See Appendix M 4.)

5. *Improvement of Arkansas River at Fort Smith, Arkansas.*—The object of this work is to remove a bar which now renders access to the city wharf very difficult at low water, and is also in the way of boats which have to pass above Fort Smith.

A survey of this locality is in progress, and as soon as plans can be perfected the sum of $10,000, provided for this work from appropriation for improvement of Mississippi, Missouri, and Arkansas Rivers, will be expended. Final estimates for the completion of the work cannot be made until this survey is completed.

Amount appropriated by act approved August 14, 1876	$10,000 00
July 1, 1877, amount expended during fiscal year	304 51
July 1, 1877, amount available	9,695 49

(See Appendix M 5.)

6. *Improvement of White River above Jacksonport.*—Nothing was done on this work during the past year. The sum of $10,000, appropriated by act approved August 14, 1876, will be expended as soon as surveys, now in progress, shall enable a definite plan to be made for carrying on the work.

The necessity for snagging operations in this stream is very great, and additional surveys are also required, and the officer in charge submits estimates for this purpose.

Amount appropriated by act approved August 14, 1876	$10,000 00
July 1, 1877, amount expended during fiscal year	183 33
July 1, 1877, amount available	9,816 67
Amount (estimated) required for completion of existing project	700,234 37
Amount that can be profitably expended in fiscal year ending June 30, 1879	60,000 00

(See Appendix M 6.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

An allotment of $5,000 was made from the appropriation of August 14, 1876, for Mississippi, Missouri, and Arkansas rivers, for surveys and examinations on the Missouri River, at *Omaha* and *Council Bluffs*, *Plattsmouth*, *Brownsville*, and *Atchison*.

Major Suter was charged with the execution of these surveys, which are now in hand and will be reported on as soon as completed.

(See Appendix M 7.)

IMPROVEMENT OF MISSISSIPPI RIVER BETWEEN THE MOUTHS OF THE ILLINOIS AND OHIO RIVERS.

Officer in charge, Col. J. H. Simpson, having under his immediate orders Capt. C. J. Allen, Corps of Engineers.

1. *Improvement of Mississippi River.*

A. *Piasa and Alton Dams.*—The funds available for these works are:

Balance July 1, 1876	$3,682 76
Appropriated August 14, 1876	15,000 00
	18,682 76

Which were to be applied to the construction of Piasa Dam and such repairs and extensions as were needed at Alton Dam. There has been expended during the fiscal year:

Piasa Dam	$7,525 64
Alton Dam	696 40
	8,222 04

The balance will be applied during the coming year. Further appropriation to the amount of $15,000 will be required to complete the works already begun.

B. *Sawyer Bend and Venice Dike.*—No work has been done at Sawyer Bend nor at Venice for want of funds. The completion of the estimated work at these points will require $53,929.10.

C. *Improvement of channel opposite Saint Louis, (closing Cahokia Chute.)*—The work done under the appropriation of $29,600 has been confined to the revetment of Arsenal Island and the construction of the abutments of the dam. The officer in charge submits a suggestion in connection with this work which is worthy of consideration; the essence of the suggestion being that since the closing of the chute will seriously increase the risk of damage to boats in the harbor by ice, as was conclusively demonstrated by the experience of the last winter, it would be advisable to make the dam a high one instead of low, as now authorized, so as to form a protected pool which may be made a secure and permanent winter harbor. The data for a full estimate of cost not being available, it is recommended that a survey and estimate be ordered.

D. *Horse-tail Bar.*—The condition of navigation at Horse-tail Bar was very unfavorable much of the season of 1876. Owing to the delay of appropriation, nothing could be done until September. Relief quickly followed the resumption of work, and it is hoped that the works are now in such state of advance that the channel will remain under their influence throughout the year. The locality has been brought to that stage of progress when protective work becomes necessary, which in this case takes the form of a longitudinal dike, an estimate for which is submitted by the officer in charge.

E. *Fort Chartres and Turkey Island.*—No work was done or contemplated at Fort Chartres until further appropriation.

A small amount of work was done at Turkey Island, which put the work in safe condition until further means are provided.

F. *Kaskaskia Bend.*—No work has as yet been done at this locality, the funds being withheld in 1876. The progress of erosion is rapid, and further appropriation is urgently needed.

G. *Liberty Island.*—Protection near Liberty Island has been extended 2,700 feet during the year; the protected part is now 6,474 feet, and benefit is being derived from the greater permanence of channel and absence of the snags from the caving banks.

H. *Devil's Island.*—The favorable results previously reported continue. The dams are still unfinished, the work of the past year being mostly limited to extending the revetments.

I. *Dickey Island to mouth of Ohio.*—Protective work to check the erosion in rear of the city of Cairo was begun in 1876. The principal effort was to secure the series of spur-dikes from destruction, and to extend the protection by continuous revetment. The work done remains perfect, and promises to be efficient. Work will be resumed to full extent of funds this season.

The officer in charge recommends that, in case Congress is not disposed to grant larger appropriations than heretofore, no new works be undertaken until those now in hand be complete. Works now begun will require $555,425.49 to provide for their completion, of which nearly two-thirds is for work begun by direct or implied order of Congress.

The officer in charge submits an estimate of $500,000 for the fiscal year ending June 30, 1879. This sum would secure the completion of the works that are now in advanced state, and also allow some new work to be begun. The appropriation of the above sum is recommended.

July 1, 1876, amount available	$15,724 68	
Amount appropriated by act approved August 14, 1876	229,600 00	
		$245,324 68
July 1, 1877, amount expended during fiscal year	138,920 54	
July 1, 1877, outstanding liabilities	5,803 69	
		144,724 23
July 1, 1877, amount available		100,600 45
Amount (estimated) required for completion of existing project		6,729,600 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		500,000 00

(See Appendix N.)

IMPROVEMENT OF MISSOURI RIVER ABOVE THE MOUTH OF THE YELLOWSTONE.

Officer in charge, First Lieut. Edward Maguire, Corps of Engineers.

The party organized for this work left Saint Paul, Minn., on June 11. The length of time required to reach the scene of operations permitted the accomplishment before the 30th of June of nothing more than a detailed survey of the locality.

During the present season it is proposed to commence operations at Dauphin's Rapids, and thence proceed to Cow Island, Two Calf Island, and such other points as the length of the season will permit. The work will consist in the removal of bowlders, reefs, and bars, and in the construction of wing-dams.

Amount appropriated by act approved August 14, 1876		$20,000 00
July 1, 1877, amount expended during fiscal year	$4,589 33	
July 1, 1877, outstanding liabilities	951 04	
		5,540 37
July 1, 1877, amount available		14,459 63
Amount that can be profitably expended in fiscal year ending June 30, 1879		30,000 00

(See Appendix O.)

IMPROVEMENT OF THE UPPER MISSISSIPPI RIVER BELOW SAINT PAUL; OF THE DES MOINES AND ROCK ISLAND RAPIDS, AND OF THE HARBORS OF FORT MADISON, BURLINGTON, AND DUBUQUE—IMPROVEMENT OF ILLINOIS RIVER.

Officer in charge, Col. J. N. Macomb, Corps of Engineers, having under his immediate orders Capt. Amos Stickney, Corps of Engineers.

1. *Improvement of the Upper Mississippi River.*—The United States steamer Montana was employed as heretofore in rendering temporary aid to navigation by dredging with Long's scraper, pulling snags, and removing leaning trees from the banks, and also in building low dams and jetties for the permanent improvement of the channel.

The great age of the Montana and the constantly increasing expense for repairs from year to year leads the officer in charge to recommend her rebuilding with an iron hull and new boilers, her machinery being still in excellent condition. The officer in charge estimates the cost for new hull, boilers, and transfer of machinery, with current expenses for the year, at $91,500.

July 1, 1876, amount available	$1,609 86
Amount appropriated by act approved August 14, 1876	30,000 00
	31,609 86
July 1, 1877, amount expended during fiscal year	14,857 65
July 1, 1877, amount available	16,752 21
Amount that can be profitably expended in fiscal year ending June 30, 1879	91,500 00

(See Appendix P 1.)

2. *Improvement of the Des Moines Rapids, Mississippi River.*—During the past season the work was directly pushed toward opening the canal, so as to be available for the passage of steamers during the low-water season of the fall of 1877, and has consisted of finishing the guard-lock, constructing the lock-gates and machinery for operating the same, building face of riprap wall on canal-embankment, finishing up prism of canal, &c.

Amount appropriated by act approved August 14, 1876		$230,000 00
July 1, 1877, amount expended during fiscal year	$106,830 97	
July 1, 1877, outstanding liabilities	17,518 73	
		124,349 70
July 1, 1877, amount available		105,650 30
Amount (estimated) required for completion of existing project		95,000 00
In addition to the above the maintenance of the work for the fiscal year ending June 30, 1879, will require		40,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		135,000 00

(See Appendix P 2.)

3. *Improvement of Rock Island Rapids of the Mississippi River.*—Owing to the lateness of appropriations, August 14, 1876, and the partial allotment of $10,000 during the fall of 1876, only 103 cubic yards of rock were broken at the foot of Moline Chain. Since the allotment of $15,000 in the spring of 1877, work of excavation at Moline Chain has been continued and 143.3 cubic yards of rock broken by June 30, 1877. It is expected to break 750 cubic yards during the present season.

There remains to complete the improvement 1,655.8 cubic yards to be broken, and 2,505.8 cubic yards of rock to be dredged at the foot of Moline Chain. For this, and for a general survey to provide the channel with landmarks, buoys, &c., and cleaning the improved cut from bowlders or obstructions thrown into it by the ice, the officer in charge

asks for an appropriation of $50,000 for the fiscal year ending June 30, 1879.

July 1, 1876, amount available		$5,729 16
Amount appropriated by act approved August 14, 1876		25,000 00
		30,729 16
July 1, 1877, amount expended during fiscal year		15,966 29
July 1, 1877, amount available		14,762 87
Amount (estimated) required for completion of existing project		50,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		50,000 00

(See Appendix P 3.)

4. *Improvement of the harbor of Fort Madison, Iowa.*—The original estimate for this work was $30,186.87. The contract for furnishing stone for building riprap dam across Niota Chute has been let and the construction begun. The officer in charge estimates that the completion of the work will cost $20,186.87.

Amount appropriated by act approved August 14, 1876		$10,000 00
July 1, 1877, amount expended during fiscal year	$312 55	
July 1, 1877, outstanding liabilities	50 88	
		363 43
July 1, 1877, amount available		9,636 57
Amount (estimated) required for completion of existing project		20,186 87
Amount that can be profitably expended in fiscal year ending June 30, 1879		20,000 00

(See Appendix P 1.)

5. *Improvement of Rush Chute and the harbor of Burlington, Iowa.*—It is proposed to build a raprap dam on a brush foundation near the head of Rush Chute, to increase the depth of water in the chute and scour out a sand-bar that threatens to destroy the navigation of the present channel.

The officer in charge estimates the cost of completing this work at $25,221.70.

Amount appropriated by act approved August 14, 1876		$10,000 00
July 1, 1877, amount expended during fiscal year	$33 33	
July 1, 1877, outstanding liabilities	38 88	
		72 21
July 1, 1877, amount available		9,927 79
Amount (estimated) required for completion of existing project		25,221 70
Amount that can be profitably expended in fiscal year ending June 30, 1879		25,500 00

(See Appendix P 1.)

6. *Removal of a bar in the Mississippi River, opposite Dubuque, Iowa.*—The original project for this work has been changed, owing to local circumstances and insufficiency of appropriation. The officer in charge proposes to remove the bar under contract by dredging as much of it as can be done with the available funds.

For the permanent improvement he suggests the building of a training-wall at an estimated cost of $25,300.

Amount appropriated by act approved August 14, 1876	$15,000 00
July 1, 1877, amount expended during fiscal year	583 18
July 1, 1877, amount available	14,416 82
Amount (estimated) required for completion of existing project	25,300 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	25,300 00

(See Appendix P 1.)

7. *Permanent improvement of the Upper Mississippi River.*—The officer in charge submits, with his reasons therefor, a project for a comprehen-

sive system of improvement of the Upper Mississippi River, at an estimated cost of $617,393, and recommends for the improvement of several of the worst localities an appropriation of $75,000.

(See Appendix P 1.)

8. *Improvement of Illinois River.*—The project for continuing the work of improving the river by dredging and building dams, jetties, and training-walls was successfully carried on, but not entirely completed, owing to suspension of work caused by long continuance of floods in the river, and the fact that of the appropriation made on the 14th August, 1876, only $10,000 was allotted for use in the remainder of the working season of 1876.

This amount was chiefly applied to the restoration of channels obstructed by detritus from summer floods, which have demonstrated the necessity of having a reserve fund and proper equipment always in readiness for such work, and the estimate for completing the improvement of Illinois River embraces the requisite amount for this purpose, which will account for its increase over the original estimate.

July 1, 1876, amount available	$39,691 86	
Amount appropriated by act approved August 14, 1876	40,000 00	
		$79,691 86
July 1, 1877, amount expended during fiscal year	49,317 72	
July 1, 1877, outstanding liabilities	2,750 00	
		52,067 72
July 1, 1877, amount available		27,624 14
Amount (estimated) required for completion of existing project		145,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		145,000 00

(See Appendix P 5.)

PRESERVATION OF THE FALLS OF SAINT ANTHONY AND IMPROVEMENT OF MISSISSIPPI RIVER ABOVE THE FALLS—CONSTRUCTION OF LOCK AND DAM AT MEEKER'S ISLAND—IMPROVEMENT OF MINNESOTA AND CHIPPEWA RIVERS, AND OF RED RIVER OF THE NORTH.

Officer in charge, Maj. F. U. Farquhar, Corps of Engineers.

1. *Improvement of Falls of Saint Anthony.*—The concrete dike has been finished. The two rolling dams on the limestone ledge were constructed and all the excavations in and under the limestone ledge above the dike were filled with well rammed gravel.

There only remains to be built of the project of the Board of Engineers of 1874 an upper wall or dike and the extension and remodeling of the apron.

It is not proposed to build the upper dike at present, as it is believed that the lower one will prove sufficient.

During the present season it is proposed to complete the work on the apron, which it is hoped will complete all the work necessary for the preservation of the Falls of Saint Anthony.

July 1, 1876, amount available	$3,062 38	
Amount appropriated by act approved August 14, 1876	120,000 00	
		$123,062 38
July 1, 1877, amount expended during fiscal year	64,081 86	
July 1, 1877, outstanding liabilities	482 12	
		64,563 98
July 1, 1877, amount available		58,498 40
Amount (estimated) required for completion of existing project		184,726 35

(See Appendix Q 1.)

2. *Improvement of Mississippi River above Falls of Saint Anthony.*—Work was commenced in May, 1877, at Battle Rapids.

During the present season it is proposed to work on the worst obstructions between Saint Cloud and Minneapolis.

Not less than $50,000 should be appropriated for a season's work, so as to enable the United States or a contractor to procure the necessary plant to carry on the work economically.

Amount appropriated by act approved August 14, 1876		$20,000 00
July 1, 1877, amount expended during fiscal year	$1,366 78	
July 1, 1877, outstanding liabilities	1,923 20	
		3,289 98
July 1, 1877, amount available		16,710 02
Amount (estimated) required for completion of existing project		124,667 50
Amount that can be profitably expended in fiscal year ending June 30, 1879.		50,000 00

(See Appendix Q 2.)

3. *Construction of lock and dam on Mississippi River at Meeker's Island, Minnesota.*—The parties holding the land-grant not having made any acceptable release, as required by the act approved March 3, 1875, no work has been done here, as the funds were not available. The State of Minnesota should annul the grant to the parties now holding the land-grant, and release the same to the United States.

July 1, 1876, amount available	$25,000 00
July 1, 1877, amount available	25,000 00
Amount (estimated) required for completion of existing project	922,121 46

(See Appendix Q 3.)

4. *Improvement of Minnesota River.*—No work has been done during the last fiscal year, as no funds were available. A contract has been made for continuing the work of removing snags, &c., from the river, commencing where the last work terminated and working down-stream.

The engineer in charge reports that since the last annual report there has been no commerce on the river above Little Rapids, nor is it probable that there will be any until the lock and dam at that place are built. At least $60,000 will be required for the commencement of that work.

July 1, 1876, amount available	$14 44	
Amount appropriated by act approved August 14, 1876	10,000 00	
		$10,014 44
July 1, 1877, amount expended during fiscal year	22 60	
July 1, 1877, outstanding liabilities	28 48	
		51 08
July 1, 1877, amount available		9,963 36
Amount (estimated) required for completion of existing project, lock and dam, Little Rapids		127,463 05
Amount that can be profitably expended in fiscal year ending June 30, 1879.		60,000 00

(See Appendix Q 4.)

5. *Improvement of Chippewa River, Wisconsin.*—The appropriation of August 14, 1876, was not made available in time for work during the last fiscal year. A contract has been entered into for constructing so much of the proposed jetties at the mouth of the river as the present small amount available will permit.

The five high sand-banks below Eau Claire should be protected, and the work of building wing-dams and jetties carried on.

For the first work $64,000 is estimated to be required, and for the latter $20,000.

Amount appropriated by act approved August 14, 1876		$10,000 00
July 1, 1877, amount expended during fiscal year	$3 94	
July 1, 1877, outstanding liabilities	24 24	
		28 18
July 1, 1877, amount available		9,971 82
Amount (estimated) required for completion of existing project		129,892 50
Amount that can be profitably expended in fiscal year ending June 30, 1879		84,000 00

(See Appendix Q 5.)

6. *Improvement of Red River of the North.*—No work was done during the last fiscal year for want of funds.

During the present season one working party will be engaged on removing snags, bowlders, and overhanging trees, and another small party will make a detailed survey of the sites for the proposed lock and dam below Goose Rapids and an examination of the river between Frog Point and the boundary line.

The officer in charge estimates that $30,000 will be required for the next season's work, including the construction and operation of dredging apparatus.

Amount appropriated by act approved August 14, 1876		$10,000 00
July 1, 1877, amount expended during fiscal year	945 93	
July 1, 1877, outstanding liabilities	508 70	
		1,454 63
July 1, 1877, amount available		8,545 37
Amount that can be profitably expended in fiscal year ending June 30, 1879		30,000 00

(See Appendix Q 6.)

IMPROVEMENT OF THE TENNESSEE AND CUMBERLAND RIVERS; OF COOSA RIVER, GEORGIA AND ALABAMA; OF HIAWASSEE RIVER, TENNESSEE; AND OF OCMULGEE, OOSTENAULA, COOSAWATTEE, AND ETOWAH RIVERS, GEORGIA.

Officer in charge, Capt. William R. King, Corps of Engineers, with Capt. L. Cooper Overman and Lieut. W. L. Marshall, Corps of Engineers, under his immediate orders.

1. *Tennessee River above Chattanooga.*—This work has been carried on, as heretofore, by hired labor, and good progress was made until January, 1877, when the appropriation became exhausted.

The work done during the year was divided among 16 different shoals, and the quantities were as follows:

Rock quarried for dams	3,595 cubic yards.
Rock excavated from channel	1,407 cubic yards.
Rock placed in dams	5,746 cubic yards.
Gravel removed from channel	105 cubic yards.
Snags removed	30

As this work is a continuation of the same system of improvement that has been carried on and is now in use on the river between Chattanooga and Kingston, there can be no doubt as to its feasibility and necessity. As but a small sum is required to complete it, it is hoped that further appropriation will be made.

July 1, 1876, amount available	$7,862 01	
Amount appropriated by act approved August 14, 1876	15,000 00	
		$22,862 01
July 1, 1877, amount expended during fiscal year	22,694 73	
July 1, 1877, outstanding liabilities	167 28	
		22,862 01

Amount (estimated) required for completion of existing project	60,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	35,000 00

(See Appendix R 1.)

2. *Tennessee River, below Chattanooga.*—This work includes the improvement of the following shoals, which are the chief obstructions to navigation on this part of the river, viz: Elk River, Big Muscle, Little Muscle, and Colbert Shoals.

At *Elk River Shoals* work has not been begun, but a careful survey has been made which shows that the Elk River can be avoided and a considerable saving in cost can be effected by building the extension of the canal on that side of the river, and taking advantage of several miles of good navigation between the foot of these shoals and the head of the old canal around the Muscle Shoals proper.

The improvement of these shoals is an essential part of the project for removing the great Muscle Shoals obstruction, of which they form an important part.

In order that the Muscle Shoals Canal may be utilized as soon as completed, it is very desirable that work on the Elk River Shoals should be begun at an early day, and this is contemplated in the estimate of the amount of money required by the officer in charge for the next fiscal year.

The *Big Muscle Shoals* improvement, which consists in the rebuilding of the old canal, has been continued during the year.

The work has been carried on under six separate contracts, with the following results:

Earth excavation	85,683 cubic yards.
Earth embankment	53,396 cubic yards.
Rock excavation	42,447 cubic yards.
Slope wall	3,436 cubic yards.
Grubbing and clearing	$45\frac{73}{100}$ acres.
Cut-stone masonry	$1,640\frac{5}{10}$ cubic yards.
Rubble masonry	$5,558\frac{2}{10}$ cubic yards.
Concrete	$39\frac{8}{10}$ cubic yards.
Removal of old locks	$3,483\frac{6}{10}$ cubic yards.

In general terms the condition of the canal at the end of the fiscal year was as follows:

Of the trunk of the canal, about 8 miles were enlarged and completed with exception of dams at the crossings of three large creeks, leaving about 6½ miles to be done.

Of the 10 locks required 3 were under contract; the foundation pits had been excavated; a large quantity of stone had been cut, and the walls of 2 of them were about two-thirds completed.

Proposals for the building of 5 other locks were received on the 15th of May, but no award has been made.

Two engineering parties located at suitable points on the canal have been engaged in making maps, plans, and cross-sections for future work, and in measuring and inspecting work done by the contractors.

As this improvement is not simply for the convenience or facility of navigation, but for overcoming an *absolute barrier to navigation*, and will unite hundreds of miles of navigable waters in the Upper Tennessee and its tributaries with the Lower Tennessee and the whole Mississippi sys-

tem, the great importance of its early completion needs no demonstration.

The *Little Muscle Shoals*, though in many respects similar to the Big Muscle Shoals, are a much less formidable obstruction.

No work has been done on these shoals, but an examination of them has been made with a view to their improvement without resorting to the expensive system of locks and dams. The engineer officer in charge of the work thinks this can be accomplished and that it is desirable to have the work commenced at once, so that it can be utilized in carrying on the work in the more serious obstruction above.

At *Colbert Shoals* work was continued with but tolerable progress, owing to high water and other causes, until November 15, 1876, when it was stopped for the season.

	Cubic yards.
Rock excavated from channel	167½
Rock put in dams	2,198
Rock quarried	1,055

It is expected that this work will be completed during the present working season.

July 1, 1876, amount available	$359,935 92	
Amount appropriated by act approved August 14, 1876	255,000 00	
		$614,935 92
July 1, 1877, amount expended during fiscal year	183,264 96	
July 1, 1877, outstanding liabilities	10,474 64	
		193,739 60
July 1, 1877, amount available		421,196 32
Amount (estimated) required for completion of existing project		3,097,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		745,000 00

(See Appendix R 2.)

3. *Improvement of Cumberland River, below Nashville.*—Three hundred and thirty-five cubic yards of rock were excavated from channel, and 1,500 cubic yards of stone put in dams at Harpeth Shoals, and 700 yards of stone quarried and 1,625 yards of stone put in dams at Davis's Ripple; a large number of snags, rocks, and overhanging trees were also removed. Work was done by hired labor and was suspended in January, the appropriation being exhausted.

July 1, 1876, amount available	$12,991 61
July 1, 1877, amount expended during fiscal year	12,654 98
July 1, 1877, amount available	336 63
Amount (estimated) required for completion of existing project	148,821 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	100,000 00

(See Appendix R 3.)

4. *Improvement of Cumberland River from Nashville to the Kentucky line.*—The work consisted of quarrying stone for dams and excavating rock and gravel from the channel. At Holliman's Island Shoals 3,285 yards of stone quarried, and 1,300 yards of gravel excavated. At Sand Shoal 2,640 yards of stone quarried, and 380 yards of rock excavated. At Cub Creek Shoals 2,385 yards of stone quarried, and 440 yards of rock and gravel excavated; also 33 logs, &c., removed from channel. At Bartlett's Bar 1,710 yards of stone quarried. All the work was done by hired labor.

Amount appropriated by act approved August 14, 1876		$15,000 00
July 1, 1877, amount expended during fiscal year	$7,817 73	
July 1, 1877, outstanding liabilities	3,315 21	
		11,132 94
July 1, 1877, amount available		3,867 06
Amount (estimated) required for completion of existing project		107,155 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		50,000 00

(See Appendix R 3.)

5. *Improvement of Cumberland River from Kentucky line to the foot of Smith's Shoals.*—Two hundred cubic yards of rock and gravel were excavated from the channel, and 300 yards of stone quarried for dams at Wild Goose Shoals. The work was done by hired labor.

Amount appropriated by act approved August 14, 1876		$10,000 00
July 1, 1877, amount expended during fiscal year	$1,247 80	
July 1, 1877, outstanding liabilities	844 37	
		2,092 17
July 1, 1877, amount available		7,907 83
Amount (estimated) required for completion of existing project		81,609 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		40,000 00

(See Appendix R 3.)

6. *Improvement of Cumberland River at Smith's Shoals.*—The work, carried on by hired labor, has been quarrying 6,120 yards of stone and building 3,060 cubic yards of dams. At this point the project is mainly to increase the number of "boating-tides" for boats engaged in the coal-trade, &c. The present work is particularly designed to improve down-stream navigation. The officer in charge believes that a system of towing, by means of a wire rope and drum, can be made available for up-stream navigation.

Amount appropriated by act approved August 14, 1876		$25,000 00
July 1, 1877, amount expended during fiscal year	$7,427 11	
July 1, 1877, outstanding liabilities	4,884 49	
		12,311 60
July 1, 1877, amount available		12,688 40
Amount (estimated) for completion of existing project		45,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		45,000 00

(See Appendix R 3.)

7. *Improvement of Cumberland River from Smith's Shoals to the Falls of the Cumberland.*—As it was deemed advisable to organize parties for the other sections first, nothing was done on this section. It is expected, however, that all the work that the appropriation will admit of will be done before the close of the present working-season.

Amount appropriated by act approved August 14, 1876	$2,000 00
July 1, 1877, amount available	2,000 00

(See Appendix R 3.)

8. *Improvement of Coosa River, Georgia and Alabama.*—An examination of the river was made from Rome to Greensport. Thirteen shoals, which formed the chief obstructions to navigation, were selected for improvement, beginning operations at Horseleg Shoals, about 1½ miles below Rome, Ga.

The work done before the end of the fiscal year consisted in building and fitting out boats, &c., and procuring tools and supplies.

Work will be commenced as soon as practicable below Greensport,

Ala., where improvements are necessary to enable the boats which now run between Rome and Greensport to reach the coal-fields in Saint Clair County, Alabama.

Amount appropriated by act approved August 14, 1876		$30,000 00
July 1 1877, amount expended during fiscal year	$239 41	
July 1, 1877, outstanding liabilities	227 71	
		467 12
July 1, 1877, amount available		29,532 88
Amount (estimated) required for completion of existing project		522,347 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		100,000 00

(See Appendix R 4.)

9. *Improvement of Hiawassee River, Tennessee.*—An examination of the river was made and work was begun about the 1st of June, at Matthews' Shoals and Magil's Island. This allowed about one month's work during the fiscal year, during which about 600 yards of rock were quarried for dams.

Work will be begun in the channel as soon as the stage of water permits.

The railroad-bridge over this river at Charleston, Tenn., will be a serious obstacle to the navigation of this river by the present class of boats, unless a draw is placed in the bridge.

Amount appropriated by act approved August 14, 1876		$10,000 00
July 1, 1877, amount expended during fiscal year	$281 20	
July 1, 1877, outstanding liabilities	703 20	
		984 40
July 1, 1877, amount available		9,015 60
Amount (estimated) required for completion of existing project		10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		10,000 00

(See Appendix R 5.)

10. *Improvement of Ocmulgee River, Georgia.*—The appropriation for the improvement of this river, act of 1876, having been made available toward the close of the year, preparations were begun for the prosecution of the work, which will begin on that part of the river below Hawkinsville. It is hoped that before the close of the season it will be practicable to begin work above Hawkinsville. A railroad-bridge at the latter point shuts off steam navigation between Hawkinsville and Macon, and if this improvement is to be fully utilized, it will be necessary to provide for the building and operating of a suitable draw in this bridge.

Amount appropriated by act approved August 14, 1876	$15,000 00
July 1, 1877, amount expended during fiscal year	46 67
July 1, 1877, amount available	14,953 33
Amount (estimated) required for completion of existing project	41,240 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	41,240 00

(See Appendix R 6.)

11. *Improvement of Oostenaula and Coosawattee Rivers.*—No work was done on these rivers during the fiscal year, for want of funds. A small balance of the former appropriation was expended for the care and preservation of boats and other property belonging to the work.

July 1, 1876, amount available	$22 06
July 1, 1877, amount expended during fiscal year	22 06
Amount (estimated) required for completion of existing project	13,208 50
Amount that can be profitably expended in fiscal year ending June 30, 1879.	13,208 50

(See Appendix R 7.)

12. *Improvement of Etowah River, Georgia.*—As soon as the appropriation of August 14, 1876, was made available for the improvement of this river, steps were taken to begin the work, but an examination having been found necessary, which was not completed within the fiscal year, no work has been done. The examination shows that a large sum will be required to make any useful improvement in this river, and it is difficult to devise a project for the economical expenditure of so small an appropriation, but as soon as such a project can be made work will be begun.

Amount appropriated by act approved August 14, 1876	$10,000 00
July 1, 1877, amount available	10,000 00
Amount (estimated) required for completion of existing project	Project incomplete

(See Appendix R 8.)

IMPROVEMENT OF THE NAVIGATION AT THE FALLS OF OHIO RIVER—SUPERINTENDENCE AND MANAGEMENT OF THE LOUISVILLE AND PORTLAND CANAL.

Officer in charge, Maj. G. Weitzel, Corps of Engineers, with Capt. Alexander Mackenzie, Corps of Engineers, under his immediate orders.

1. *Improvement of the Falls of Ohio River.*—The river has been at so high a stage during the year that nothing could be done.

No further appropriation is required for this work.

July 1, 1876, amount available	$89,749 30
July 1, 1877, amount expended during fiscal year	7,098 62
July 1, 1877, amount available	82,650 68

(See Appendix S 1.)

2. *Superintendence, management, and repair of the Louisville and Portland Canal.*—During the year 3,439 vessels have been passed through the locks, and 95,282 cubic yards of sediment removed by the dredges. The repairs on the tow-boat have been completed, and a large fire and wrecking pump added to the boat's outfit; a new hull and a new boiler have been built for dredge No. 2; dump-scow No. 4 has been rebuilt; the shop has been extended, and one planer, one boring-machine, one circular saw, and one grindstone set up; new guard-gates were built and set up at head of new locks; new gates for the head of the canal were almost completed; new winding-machinery was provided for middle gates of the new locks; Eighteenth-street bridge was thoroughly repaired; foundation was completed and building commenced for superintendent's office; a second fire-cistern was commenced; slopes near new locks were partially graded and sodded, and the toll-collector's house and workshops painted.

In addition to the above the mechanics have been employed in repairs on machinery and accessories of the canal, and in making new machinery and tools, and the laborers in passing and docking boats and general work.

Cash on hand July 1, 1877	$44,832 62

(See Appendix S 2.)

IMPROVEMENT OF THE OHIO, MONONGAHELA, AND LITTLE KANAWHA RIVERS.

Officer in charge, Maj. W. E. Merrill, Corps of Engineers, having under his immediate orders Lieut. F. A. Mahan, Corps of Engineers.

1. *Improvement of the Ohio River.*—The only works of construction carried on during the past fiscal year were the repair of the old dike at

the Trap, a few miles below Pittsburgh, and the extension of the dike just above Evansville, Ind.

The dike at the Trap was built up to a level with the stage of 6½ feet in the channel for a length of 985 linear feet, of which length, 735 feet was composed of solid timber walls filled in with furnace-slag and stone. No cheaper method of construction would resist the shock of currents of ice across the dike. The work thus far built has stood well. During the present season the dike will be further extended about 2,000 feet.

The dike at Evansville has been completed. As far as now known it has fully accomplished the results desired. Its total length is 2,000 feet, of which a length of 1,800 feet has a width of 50 feet, and the remainder a width of 40 feet.

The Jackson Rock in the Grand Chain, a well-known and serious obstruction, has been entirely removed by surface-blasting.

The snag-boat E. A. Woodruff has done good service in removing obstructions. During 1876 it removed and destroyed 915 snags and 21 wrecks. The heaviest snag weighed about 96 tons, the average weight being 8¼ tons.

The United States dredges Ohio and Oswego have done the following dredging during the fiscal year:

	Cubic yards.
Raccoon Island	16,970
Deadman's Island	16,080
Fish Creek Island	26,345
Captina Island	7,830
Cumberland Island	11,788
Total	79,013

On the 30th of November the dredges went up the Wabash, and returned to the Ohio on March 1, 1877. During the fiscal year, besides dredging they removed two wrecks from the channel.

The work at Cumberland Island consisted in making an opening 420 feet in width through the old dam across the Ohio at this point.

No work was done during the fiscal year on the movable dam at Davis Island, but on the 17th of March the Pennsylvania legislature passed an act ceding jurisdiction to the United States over the land required for this purpose, and the legal authorities of the Government are now taking the proper steps to condemn such land as cannot be purchased on reasonable terms. As soon as possession of the land is obtained the work of construction will be pushed with vigor.

The officer in charge submits the following estimate for the fiscal year 1878–'79:

For snag-boat and dredges	$60,000 00
For riprap dams, office expenses, and contingencies	100,000 00
For movable dam at Davis Island	365,000 00
Total amount required	525,000 00

July 1, 1876, amount available	$117,020 95	
Amount appropriated by act approved August 14, 1876	175,000 00	
		292,020 95
July 1, 1877, amount expended during fiscal year	110,577 59	
July 1, 1877, outstanding liabilities	6,924 00	
		117,501 59
July 1, 1877, amount available		174,519 36
Amount that can be profitably expended in fiscal year ending June 30, 1879		525,000 00

(See Appendix T 1.)

Owing to an impression which has been manifested that the improvement of the navigation of the Ohio River by locks and dams with adjustable chutes is not admissible when applied to the peculiar navigation of that river, a board of engineer officers was convened with the view of taking into consideration and replying to the arguments in opposition to that plan, embraced in a memorial to Congress, December 23, 1875, by the Coal Exchange and Steamboatmen's Association of Pittsburgh.

The report of the board, together with the memorial in question, and other communications relating to this subject, will be found in Appendix T 2.

2. *Improvement of the Monongahela River.*—All the funds appropriated for the construction of a lock and dam at Hoard's Rocks, West Virginia, have been expended. The lock is complete, except miter and lift walls, and the dam is about one-third built. The stone necessary for the completion of the work is quarried and on the ground. For reasons set forth at length in the report of the officer in charge an additional appropriation of $25,000 will be required for this work. An appropriation is also recommended for the lock at Laurel Run, which, when finished, together with one lock and dam to be built by the Monongahela Navigation Company, will complete the slack-water from Pittsburgh to Morgantown.

Estimate for the fiscal year 1878-'79.

For completion of lock and dam at Hoard's Rocks	$25,000 00
For lock at Laurel Run, (omitting miter-walls, gates, and valves)	60,000 00
Total amount required	85,000 00
July 1, 1876, amount available	37,814 61
July 1, 1877, amount expended during fiscal year	37,295 07
July 1, 1877, amount available	519 54
Amount (estimated) required for completion of existing project	214,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	85,000 00

(See Appendix T 3.)

3. *Improvement of the Little Kanawha River.*—Work on the improvement of this river did not begin until the middle of June, but it is rapidly progressing. The officer in charge recommends an additional appropriation for removing obstructions in the main river and its west fork, and also for the construction of a lock and dam to continue the existing slack-water.

Estimate for the fiscal year 1878-'79.

For removing obstructions	$5,000 00
For the construction of a lock	40,000 00
Total amount required	45,000 00
Amount appropriated by act approved August 14, 1876	7,300 00
July 1, 1877, outstanding liabilities	550 00
July 1, 1877, amount available	6,750 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	45,000 00

(See Appendix T 4.)

EXAMINATIONS AND SURVEYS FOR IMPROVEMENT.

To comply with a resolution of the House of Representatives of March 2, 1877, Major Merrill has been instructed to make, and is now engaged upon, examinations and surveys *to determine the best method of protecting, by harbors of refuge or otherwise, the commerce of Cincinnati during ice-floods in the Ohio.*

IMPROVEMENT OF WABASH RIVER, INDIANA.

Officers in charge, Maj. W. E. Merrill, Corps of Engineers, to January 22, 1877; since which time Maj. Jared A. Smith, Corps of Engineers.

The contractors for building a dam across New Harmony Cut-off having failed to prosecute the work as required, their contract was annulled, and the officer in charge proceeded to complete the dam with hired labor. The work was finally finished in January, 1877. Early in February, during a high stage of water with floating ice, a severe breach occurred in the island end of the dam, which entailed a large amount of labor for its repair. It is expected to be put in good condition during the present season.

At Warwick's Ripple the contractor found it impracticable to proceed owing to high water, and for that reason his contract was extended.

At Little Chain Cut-off considerable work has been done in dredging and removing snags in order to turn the channel of the river and save the expensive excavation, which will otherwise be necessary, through a ledge of rock in the river's bed; 14,125 cubic yards of material have been dredged and deposited on the opposite shore, and 226 snags have been removed. This work will be continued during the season. It is proposed as far as possible in the ensuing year to complete the improvements required below Grand Rapids, and if deemed advisable the work on the lock at that point will be begun.

The act of August 14, 1876, appropriated $70,000 for "improving Wabash River, Indiana." As it was not available until near the close of the fiscal year it remains for expenditure the ensuing year.

Estimates for 1878–1879.

The following estimate has been submitted with the last two annual reports, and is repeated here, viz:

For rebuilding Grand Rapids lock		$130,000 00
For engineering and contingencies		15,000 00
		145,000 00
July 1, 1876, amount available	$34,114 88	
Amount appropriated by act approved August 14, 1876	70,000 00	
		104,114 88
July 1, 1877, amount expended during fiscal year		18,435 27
July 1, 1877, amount available		85,679 61
Amount that can be profitably expended in fiscal year ending June 30, 1879		100,000 00

(See Appendix U.)

TRANSPORTATION-ROUTES TO THE SEABOARD.

The surveys of the *third subdivision of the central route,* designated as—

A connection by canal or a freight-railway from the Ohio or Kanawha River, near Charleston, by the shortest and most practicable route through West Virginia to tide-water in Virginia—

were made, in compliance with the provisions of the act of June 23, 1874, under the supervision of Maj. William P. Craighill, Corps of Engineers, who submitted a final report, dated November 10, 1876.

This report was printed as Executive Document No. 15, Senate, Forty-fourth Congress, second session.

(See also Appendix V.)

BRIDGING THE NAVIGABLE WATERS OF THE UNITED STATES.

1. The river and harbor act of June 23, 1866, made provision for examining and reporting upon the subject of constructing railroad-bridges across the Mississippi, between Saint Paul, Minn., and Saint Louis, Mo., upon such plans of construction as would offer the least impediment to the navigation of that river.

This subject was, at the time, assigned to Maj. G. K. Warren, Corps of Engineers, but his report thereon has been delayed from the pressure of other important duties. Since the date of the act there has been an almost continued increase of new and important data. Previous to the past fiscal year the surveys which Major Warren had caused to be made did not include the bridges and changes made since 1870, but during the year a survey has been made of those bridges and much additional information has been obtained.

As all the material has now been collected, it is expected that the report will be received in time to be submitted to Congress early in the approaching session.

(See Appendix W 1.)

2. To enable the Secretary of War to comply with the requirements of an act for the further security of navigation on the Mississippi River, approved March 3, 1875, a board of engineer officers was constituted to consider the subject of causing sheer-booms to be placed on the end of all or any bridge-piers on the Mississippi for the better security and convenience of the navigation of the river for rafts of logs and timber.

The report of the board, with my letter of transmission, was printed in Executive Document No. 41, House of Representatives, Forty-fourth Congress, second session, and will be found in Appendix W 2 of this report. I again invite attention to the recommendations therein contained.

RAILROAD ACCIDENTS.

A bill, H. R. No. 4558, Forty-fourth Congress, second session, was introduced by Hon. J. A. Garfield, to provide for the more thorough investigation of accidents on railroads; and a communication, containing remarks upon the bill, from Mr. T. C. Clarke, civil engineer, was submitted by Mr. Garfield to the President and referred to the War Department and thence to this office.

The papers in the case were subsequently transmitted to the Board of Engineers for Fortifications for consideration and suggestion and such modification or amendment to the bill as it might see fit to propose.

The reply of the Board, together with the communication of Mr. Clarke and a copy of the bill in question, will be found in Appendix W 4 of this report.

LAKE HARBORS AND RIVERS.

HARBOR IMPROVEMENTS AT SUPERIOR CITY, SUPERIOR BAY, AND DULUTH, LAKE SUPERIOR.

Officer in charge, Maj. F. U. Farquhar, Corps of Engineers.

1. *Improvement of harbor at Duluth, Minnesota.*—Three hundred and ten cords of stone were placed as an enrockment along the channel-face of the north pier of the canal. A contract has been made for continuing the dredging in the inside harbor. To continue this dredging economically, the officer in charge recommends an annual appropriation of $50,000 until the work is completed.

July 1, 1876, amount available	$4,317 06	
Amount appropriated by act approved August 14, 1876	15,000 00	
		$19,317 06
July 1, 1877, amount expended during fiscal year	2,601 35	
July 1, 1877, outstanding liabilities	32 12	
		2,633 47
July 1, 1877, amount available		16,683 59
Amount that can be profitably expended in fiscal year ending June 30, 1879.		50,000 00

(See Appendix X 1.)

2. *Improving natural entrance to the Bay of Superior.*—Some repairs were made to the inner end of the Minnesota pier. There has been no shoaling in the channel-way between the piers.

During the present season it is proposed to protect Minnesota Point at a place where the winds have cut it down.

As the piers will soon require some repairs, the officer in charge recommends that $7,000 be appropriated for this and other contingencies.

July 1, 1876, amount available	$89 46	
Amount appropriated by act approved August 14, 1876	3,000 00	
		$3,089 46
July 1, 1877, amount expended during fiscal year		589 46
July 1, 1877, amount available		2,500 00
Amount (estimated) required for repairs of existing works		7,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		7,000 00

(See Appendix X 2.)

HARBORS ON LAKE SUPERIOR, (EXCEPT DULUTH AND SUPERIOR CITY,) ON GREEN BAY, AND ON THE WESTERN SHORE OF LAKE MICHIGAN, NORTH OF MILWAUKEE, WISCONSIN.

Officer in charge, Maj. Henry M. Robert, Corps of Engineers.

1. *Ontonagon Harbor, Michigan.*—The work under contract has been completed. Superstructure is being built over the unfinished cribs, which, when done, will make the piers each about 1,300 feet long; 2,500 feet being the length originally planned. It is proposed to continue the pier-extension, for which purpose $30,000 is asked for by the officer in charge.

This is an important work, being the only available harbor of refuge on a long stretch of coast.

July 1, 1876, amount available	$4,793 74	
Amount appropriated by act approved August 14, 1876	15,000 00	
		$19,793 74
July 1, 1877, amount expended during fiscal year		4,845 39
July 1, 1877, amount available		14,948 35
Amount (estimated) required for completion of existing project		193,170 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		30,000 00

(See Appendix Y 1.)

2. *Eagle Harbor, Michigan.*—The work of blasting a channel across the ledge of rock which obstructs the entrance to this harbor, commenced in 1875, was continued and is still in progress. The work of drilling and blasting is nearly finished and the broken rock is being removed by a dredge.

Although the project being carried out contemplates a further expenditure of $186,362, the officer in charge does not consider such a large additional outlay upon this harbor justifiable, and proposes, after the channel is cut through the ledge of rock, to build short guiding crib-piers, one on each side of the channel, when he thinks the harbor will need no further improvement. This will require a further appropriation of $10,000 for the next fiscal year, and will reduce the expense of the improvement at this harbor, from the estimate, by $176,362.

July 1, 1876, amount available	$9,933 99	
Amount appropriated by act approved August 14, 1876	12,000 00	
		$21,933 99
July 1, 1877, amount expended during fiscal year		8,345 22
July 1, 1877, amount available		13,588 77
Amount (estimated) required for completion of existing project		186,362 36
Amount that can be profitably expended in fiscal year ending June 30, 1879		10,000 00

(See Appendix Y 2.)

3. *Marquette Harbor, Michigan.*—Some repairs were made to the breakwater. No other work is contemplated during the present season. The recommendation for an increase of 400 feet to the length of the breakwater, made during the last two years, is renewed. The extension will cost $68,000, and if made, the work will then have cost $10,870 less than originally estimated, and will be 410 feet longer than originally proposed. For this purpose $20,000 will be required for the next fiscal year.

July 1, 1876, amount available	$1,083 45	
Amount appropriated by act approved August 14, 1876	2,000 00	
		$3,083 45
July 1, 1877, amount expended during fiscal year		592 55
July 1, 1877, amount available		2,490 90
Amount (estimated) required for completion of project recommended		68,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		20,000 00

(See Appendix Y 3.)

4. *Menomonee Harbor, Michigan and Wisconsin.*—The contract of the previous year was extended to cover the working season of 1876. Forty thousand five hundred and eighty-four and two-tenths cubic yards of

dredging was done, which, with the quantity previously removed, makes a total of 134,061$\frac{8}{10}$ cubic yards of material removed under this contract. Eighty-three thousand cubic yards were dredged in the harbor by private parties, and the south pier received extensive repairs. Five cribs are being built in extension of the piers during the present season by contract, and it is proposed to continue the pier-extension during the fiscal year 1878–'79.

July 1, 1876, amount available	$12,245 47	
Amount appropriated by act approved August 14, 1876	8,000 00	
		$20,245 47
July 1, 1877, amount expended during fiscal year		10,714 24
July 1, 1877, amount available		9,531 23
Amount (estimated) required for completion of existing project		79,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		25,000 00

(See Appendix Y 4.)

5. *Green Bay Harbor, Wisconsin.*—The east and west pier-revetments were repaired where damaged by the moving ice in the winter of 1875–'76, and the pile-protection to the east pier has been extended. Dredging on the line of the improvement will be continued during the present season as far as the available funds will permit. The continuation of the same work is proposed during the next fiscal year.

This harbor should be pushed to an early completion, as, independently of the local trade, it forms the lake-outlet for the Fox and Wisconsin river improvement. A straight channel of 14 feet water through the flats at the mouth of the Fox River is the object aimed at. To preserve it when completed will require a small annual appropriation.

July 1, 1876, amount available	$419 16	
Amount appropriated by act approved August 14, 1876	8,000 00	
		$8,419 16
July 1, 1877, amount expended during the fiscal year		2,274 73
July 1, 1877, amount available		6,144 43
Amount (estimated) required for completion of existing project		27,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		15,000 00

(See Appendix Y 5.)

6. *Harbor of Refuge at Sturgeon Bay Canal, Wisconsin.*—No appropriation has been made and no work done since 1874. The canal company has resumed work on the canal. The pile piers require repairs, and the recommendation of last year that $5,000 be appropriated for this purpose, and for such repairs as may be required from time to time, is renewed by the officer in charge. The piers will be partly filled this summer with the small amount on hand. The work should not be permitted to go to ruin for want of repairs, as the harbor will eventually be an important point when the canal is completed.

July 1, 1876, amount available	$401 21
July 1, 1877, amount available	401 21
Amount (estimated) required for completion of existing project	130,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879, for repairs	5,000 00

(See Appendix Y 6.)

7. *Ahnepee Harbor, Wisconsin.*—The United States dredge was put in working order, and is engaged in removing the rock blasted in the bed of the river in 1876. Superstructures are being built on the seven cribs sunk in 1875 by contract. The operations proposed for the next fiscal

year are the continuation of the rock work commenced in the spring of 1876, under the modified plan of December 16, 1875.

July 1, 1876, amount available	$284 91	
Amount appropriated by act approved August 14, 1876	8,000 00	
		$8,284 91
July 1, 1877, amount expended during fiscal year		1,287 86
July 1, 1877, amount available		6,997 05
Amount (estimated) required for completion of existing project		87,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		22,000 00

(See Appendix Y 7.)

8. *Two Rivers Harbor, Wisconsin.*—Repairs were made on the pile-revetment at the shore end of the north pier, which was damaged during a storm. Day-marks were erected on the sunken cribs at the end of each pier. Superstructure is now being built on the six cribs sunk in 1875. The piers will be further extended, sand-proof lining placed on the pile piers, and some dredging done in the channel with the amount required for the next fiscal year.

July 1, 1876, amount available	$1,012 65	
Amount appropriated by act approved August 14, 1876	5,000 00	
		$6,012 65
July 1, 1877, amount expended during fiscal year		1,043 53
July 1, 1877, amount available		4,969 12
Amount (estimated) required for completion of existing project		155,588 80
Amount that can be profitably expended in fiscal year ending June 30, 1879		20,000 00

(See Appendix Y 8.)

9. *Manitowoc Harbor, Wisconsin.*—Superstructure was built over two cribs sunk in 1875, the work being done by hired labor and purchase in open market. General repairs to the oldest portion of the piers were commenced in the spring and are still in progress. The operations contemplated during the next fiscal year are the extension of the piers and dredging.

This port, being the oftenest sought as a harbor of refuge of all on the northwestern shore of Lake Michigan, should be improved, so as to admit vessels drawing 16 feet water in all weather, at as early a date as possible.

July 1, 1876, amount available	$1,143 48	
Amount appropriated by act approved August 14, 1876	8,000 00	
		$9,143 48
July 1, 1877, amount expended during fiscal year		7,011 79
July 1, 1877, amount available		2,131 69
Amount (estimated) required for completion of existing project		36,682 54
Amount that can be profitably expended in fiscal year ending June 30, 1879		20,000 00

(See Appendix Y 9.)

10. *Sheboygan Harbor, Wisconsin.*—The work of repair (commenced in 1875) on the old portion of the piers was continued, and though temporarily suspended since June 1, will be resumed about September 1, and continued through the fiscal year 1878–'79, should funds be appropriated. The decay of the old superstructure, and the necessity for dredging, together with the elevation of the lake-bed since work was commenced, render additional outlay necessary. The cost has so far exceeded the estimates by $5,351, but over $15,450 have been expended on repairs since July 1, 1875.

July 1, 1876, amount available	$2,400 24	
Amount appropriated by act approved August 14, 1876	6,000 00	
		$8,400 24
July 1, 1877, amount expended during fiscal year		5,351 00
July 1, 1877, amount available		3,049 24
Amount that can be profitably expended in fiscal year ending June 30, 1879, for repairs		6,000 00

(See Appendix Y 10.)

11. *Port Washington Harbor, Wisconsin.*—Repairs were made on the embankment between the harbor and the Sauk River, and to the pile revetment of the south bank of the harbor. The United States dredge was put in working order in anticipation of an appropriation in time to work during the season of 1876. Repairs were also made on the north pier. The dredging of the north basin will be commenced this season and continued, according to the modified plan, during the next fiscal year, should further appropriation be made.

July 1, 1876, amount available	$1,321 25	
Amount appropriated by act approved August 14, 1876	8,000 00	
		$9,321 25
July 1, 1877, amount expended during fiscal year		1,776 07
July 1, 1877, amount available		7,545 18
Amount (estimated) required for completion of existing project		66,527 17
Amount that can be profitably expended in fiscal year ending June 30, 1879.		12,000 00

(See Appendix Y 11.)

HARBORS OF MILWAUKEE, RACINE, AND KENOSHA, LAKE MICHIGAN—IMPROVEMENT OF FOX AND WISCONSIN RIVERS.

Officer in charge, Maj. D. C. Houston, Corps of Engineers, with Capt. G. J. Lydecker (to May 5, 1877) and Lieut. F. A. Hinman, Corps of Engineers, under his immediate orders.

1. *Milwaukee Harbor, Wisconsin.*—The stone superstructure over the north pier was completed last season for a distance of 560 feet, except pavement between the side walls and part of the filling between.

The sum of $5,000 of the appropriation of August 14, 1876, was made available in September, 1876, and a part of it applied to the construction of a pile and timber protection for a distance of 560 feet on the channel-face of the north pier.

The balance of the appropriation ($21,000) was made available in April, 1877, and is now being applied to rebuilding the old superstructure of the south pier.

It is expected this season to complete the pavement of the north pier as far as the walls are laid, and to make some necessary repairs.

The future work contemplated at present is the completion of the stone superstructure over the north pier, and some additional filling in the outer cribs of both piers.

July 1, 1876, amount available	$7,575 87	
Amount appropriated by act approved August 14, 1876	26,000 00	
		$33,575 87
July 1, 1877, amount expended during fiscal year	10,314 73	
July 1, 1877, outstanding liabilities	5,233 94	
		15,548 67
July 1, 1877, amount available		18,027 20
Amount (estimated) required for completion of existing project		30,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		30,000 00

(See Appendix Z 1.)

2. *Racine Harbor, Wisconsin.*—No work was done in 1876, except some minor repairs needed for preservation of the north pier.

The appropriation of August 14, 1876, ($8,000,) was made available in April, 1877, and is being applied to rebuilding about 600 feet of the old timber superstructure of the north pier. It is expected to complete this work this season. The future work contemplated at present is the extension of the north pier 150 feet.

July 1, 1876, amount available	$244 57	
Amount appropriated by act approved August 14, 1876	8,000 00	
		$8,244 57
July 1, 1877, amount expended during fiscal year	463 95	
July 1, 1877, outstanding liabilities	1,637 30	
		2,101 25
July 1, 1877, amount available		6,143 32
Amount (estimated) required for completion of existing project		30,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		21,000 00

(See Appendix Z 2.)

3. *Kenosha Harbor, Wisconsin.*—No work was done at this harbor in 1876, except some minor repairs.

The appropriation of August 14, 1876, ($8,000,) was made available in April, 1877, and this season the superstructure has been rebuilt over the two outer cribs of the north pier 100 feet in length, and their filling which had settled replaced.

Some dredging will also be needed this season.

The future work required at this harbor consists in general repairs to old work, dredging in channel and extension of the piers from time to time.

July 1, 1876, amount available	$361 83	
Amount appropriated by act approved August 14, 1876	8,000 00	
		$8,361 83
July 1, 1877, amount expended during fiscal year	874 72	
July 1, 1877, outstanding liabilities	3,415 86	
		4,290 58
July 1, 1877, amount available		4,071 25
Amount (estimated) required for completion of existing project		80,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		17,000 00

(See Appendix Z 3.)

4. *Improvement of the Fox and Wisconsin rivers.*—The improvement of these rivers is being carried on in accordance with the plan heretofore reported, and the results are given in detail in the accompanying reports in Appendix Z.

It is expected this season to complete all the new locks and dams, except the coping on four locks on the upper Fox, to excavate canals at these four locks, and put in temporary dams at same, so as to complete the system of slack-water navigation in the Fox River.

The further improvement will consist in dredging and in rebuilding old works. The old locks are being put in the best working order practicable.

No work has been done on the Wisconsin River since 1875, owing to insufficient funds.

July 1, 1876, amount available	$159,442 17	
Amount appropriated by act approved August 14, 1876	270,000 00	
		$429,442 17
July 1, 1877, amount expended during fiscal year	269,448 68	
July 1, 1877, outstanding liabilities	14,685 48	
		284,134 16
July 1, 1877, amount available		145,308 01
Amount (estimated) required for completion of existing project		2,975,663 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		750,000 00

(See Appendix Z 4.)

HARBORS OF CHICAGO, CALUMET, MICHIGAN CITY, AND NEW BUFFALO, LAKE MICHIGAN.

Officers in charge, Maj. G. L. Gillespie, Corps of Engineers, to May 5, 1877, since which time Capt. G. J. Lydecker, Corps of Engineers.

1. *Chicago Harbor, Illinois.*—Three courses of superstructure, with stone filling and planking, were built on the north pier extension, 600 feet in length; 24 oak piles driven and capped as a protection to the pier-head. The close pile protection on sea side of breakwater was extended 292 feet. Some of the breakwater-cribs were partly refilled with stone, to provide against settlement which has taken place since their completion in 1875.

The unexpended balance available at the close of the year will be applied to repairing the old piers and extending pile protection at end of north pier.

An appropriation of $150,000 is recommended by the officer in charge for the fiscal year ending June 30, 1879, to be applied as follows: $100,000 for continuation of breakwater; $40,000 for dredging in outer harbor; $10,000 for repairs of old piers.

July 1, 1876, amount available	$15,524 92
Amount appropriated by act approved August 14, 1876	5,000 00
	20,524 92
July 1, 1877, amount expended during fiscal year	17,855 48
July 1, 1877, amount available	2,669 44
Amount that can be profitably expended in fiscal year ending June 30, 1879.	150,000 00

(See Appendix A A 1.)

2. *Calumet Harbor, Illinois.*—Work at this harbor was not commenced during the fiscal year until the 1st of May; since then 13,886 cubic yards have been dredged between the piers and through the outer bar.

Materials for extending the north pier 150 feet have been purchased, and the work of framing cribs commenced. Dredging operations will soon be suspended, when about 18,000 cubic yards will have been excavated. The extension of the north pier will exhaust the balance of the appropriation.

The original estimate of this improvement was, in round numbers, $300,000, of which $250,000 has been appropriated to date, leaving $50,000 to complete, all of which is asked by the officer in charge for the fiscal year ending June 30, 1879. This is needed to complete the dredging and to extend the piers into deep water.

July 1, 1876, amount available	$1,807 33	
Amount appropriated by act approved August 14, 1876	20,000 00	
		$21,807 33
July 1, 1877, amount expended during fiscal year	6,648 29	
July 1, 1877, outstanding liabilities	2,307 80	
		8,956 09
July 1, 1877, amount available		12,851 24
Amount (estimated) required for completion of existing project		50,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		50,000 00

(See Appendix A A 2.)

3. *Michigan City Harbor, Indiana.*—The principal work contemplated at the beginning of the year was to place the superstructure on twelve cribs of the breakwater which were sunk during the previous season. No money became available for this purpose until the middle of September, and it was the 1st of October before work was fairly commenced. The season was then so far advanced that it was almost impossible to make much progress, the work at the beginning being from 1 to 3 feet under water. By the end of November there was one course of the superstructure above the water over the entire length of the breakwater, except one crib, and the second course was placed for a distance of 200 feet; the entire work was well filled with stone. A terrific gale, lasting four days, (November 28 to December 1,) destroyed all that had been accomplished, and the severity of the weather precluded any further operations at that time. Work was resumed May 1, and continued until the end of the year in repairing the damage done to the unfinished work by the gale referred to, and by subsequent storms during the winter. The bulk of the last appropriation has been exhausted in this way. The experience of the past year at this exposed point indicates the urgent need of making the next appropriation sufficient to complete the work, at least so far as necessary to avoid damage and loss such as that above reported. The amount required for this purpose is $100,000, to be applied as follows:

For completing construction of breakwater		$75,000 00
For refilling and repairing harbor-piers		5,000 00
For dredging in outer harbor		20,000 00
July 1, 1876, amount available	$1,191 05	
Amount appropriated by act approved August 14, 1876	35,000 00	
		$36,191 05
July 1, 1877, amount expended during fiscal year	25,579 12	
July 1, 1877, outstanding liabilities	1,621 82	
		27,200 94
July 1, 1877, amount available		8,990 11
Amount (estimated) required for completion of existing project		120,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		100,000 00

(See Appendix AA 3.)

4. *New Buffalo Harbor, Michigan.*—There was no work done here during the year. None is contemplated for the ensuing year.

There has been no appropriation for this improvement since 1872, and none is now recommended.

July 1, 1876, amount available	$5,541 85
July 1, 1877, amount expended during fiscal year	528 41
July 1, 1877, amount available	5,013 44

(See Appendix A A 4.)

HARBORS ON THE EASTERN SHORE OF LAKE MICHIGAN.

Officer in charge, Maj. S. M. Mansfield, Corps of Engineers.

1. *Charlevoix Harbor, Michigan.*—This is a new work, for which $10,000 was appropriated in the act of August 14, 1876. This will be expended this season in dredging a channel of 11 feet, and constructing a south pier to protect its mouth from being closed by the drift of sand along the beach. The work is under contract and progressing.

In further continuance of this work of improvement $30,000 can be very profitably expended during the next fiscal year.

Amount appropriated by act approved August 14, 1876		$10,000 00
July 1, 1877, amount expended during fiscal year	$135 57	
July 1, 1877, outstanding liabilities	4,620 19	
		4,755 76
July 1, 1877, amount available		5,244 24
Amount (estimated) required for completion of existing project		176,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		30,000 00

(See Appendix B B 1.)

2. *Frankfort Harbor, Michigan.*—For want of sufficient funds no work was attempted during the fiscal year beyond some slight repairs to the existing work. Three thousand dollars was appropriated to this work by act of August 14, 1876. This, with the balance of former appropriation, will permit of the addition of one crib to the south pier; the raising of the pier for a distance of 300 feet to the proper level above water; the replacing of broken timbers by new ones, and the filling of the outer crib of the south pier, which is almost entirely empty.

There is an available water-way of 11 feet between the piers.

The harbor is an important one, owing to its locality, and should have a permanent depth of at least 14 feet.

To carry out the recommendations made yearly since 1872 will require $22,000, which amount can be profitably expended next season.

July 1, 1876, amount available	$4,402 42	
Amount appropriated by act approved August 14, 1876	3,000 00	
		$7,402 42
July 1, 1877, amount expended during fiscal year	1,141 96	
July 1, 1877, outstanding liabilities	2,810 15	
		3,952 11
July 1, 1877, amount available		3,450 31
Amount (estimated) required for completion of existing project		22,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		22,000 00

(See Appendix B B 2.)

3. *Manistee Harbor, Michigan.*—During the year some needed repairs were made to the piers, and an obstruction of sand at the bend in the river was removed, affording temporary relief to navigation.

There is an available channel-way of about 10 feet between the Government piers.

Under the appropriation of August 14, 1876, ($14,000,) a contract has been made to remove the point of sand in bend of river and revet the bank for a distance of 320 feet, and dredge the channel to a depth of 12 feet..

As the further extension of the piers is demanded, and according to the estimates a balance of $76,771 is required for the purpose, the sum of $30,000 can be very profitably expended next season.

July 1, 1876, amount available	$10,381 78	
Amount appropriated by act approved August 14, 1876	14,000 00	
		$24,381 78
July 1, 1877, amount expended during fiscal year	10,564 42	
July 1, 1877, outstanding liabilities	6,647 57	
		17,211 99
July 1, 1877, amount available		7,169 79
Amount (estimated) required for completion of existing project		76,771 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		30,000 00

(See Appendix B B 3.)

4. *Ludington Harbor, Michigan.*—But little was accomplished during the year with the balance of the appropriation of 1875.

During a severe gale of the 8th of December, the end crib of south pier was forced out and lodged upon the beach. It will be recovered and placed in the north pier this season.

The harbor is in good condition, having a channel of 12 feet through the center between the piers.

Ten thousand dollars was appropriated by act of August 14, 1876, and will be applied chiefly to pier-extension.

The work is progressing under contract.

The recommendations for pier-extension are renewed. The estimates amount to $26,000, which sum can be profitably expended next season.

July 1, 1876, amount available	$2,037 03	
Amount appropriated by act approved August 14, 1876	10,000 00	
		$12,037 03
July 1, 1877, amount expended during fiscal year	1,826 47	
July 1, 1877, outstanding liabilities	6,167 53	
		7,994 00
July 1, 1877, amount available		4,043 03
Amount (estimated) required for completion of existing project		26,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		26,000 00

(See Appendix B B 4.)

5. *Pentwater Harbor, Michigan.*—The Government dredge removed from the channel 7,230 cubic yards of sand; and the revetment received some slight repairs; exhausting the appropriation of 1873.

The piers are in fair condition.

The north side revetment will be carried eastward 500 feet or more this season, with the appropriation now available. This work is under contract.

The recommendations and estimates made annually since 1873 are renewed, and the unappropriated balance of $39,200 can be profitably expended next season.

July 1, 1876, amount available	$1,703 63	
Amount appropriated by act approved August 14, 1876	10,000 00	
		$11,703 63
July 1, 1877, amount expended during fiscal year	1,874 47	
July 1, 1877, outstanding liabilities	5,957 86	
		7,832 33
July 1, 1877, amount available		3,871 30
Amount (estimated) required for completion of existing project		39,200 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		39,200 00

(See Appendix B B 5.)

6. *White River Harbor, Michigan.*—Some repairs were made to the piers, and the Government dredge removed a wreck and 12,480 cubic yards of sand from the channel, exhausting the appropriation of 1875.

From the appropriation of August 14, 1876, $1,000 was allotted late in the season to secure the work for the winter, and expended.

This spring the channel was found available for vessels drawing only 9 feet of water.

The Government dredge has opened a channel of 10 feet, and some repairs have been made to the revetments. Work to the extent of available funds will be done later in the season, in dredging, &c.

Thirty-one thousand eight hundred and ninety-one dollars remain to be appropriated for pier-extension, to complete the present project. It can be profitably expended during the next working-season.

July 1, 1876, amount available	$2,080 46
Amount appropriated by act approved August 14, 1876	5,000 00
	7,080 46
July 1, 1877, amount expended during fiscal year	4,150 79
July 1, 1877, amount available	2,929 67
Amount (estimated) required for completion of existing project, (including dredging)	36,891 56
Amount that can be profitably expended in fiscal year ending June 30, 1879.	32,000 00

(See Appendix B B 6.)

7. *Muskegon Harbor, Michigan.*—The work at this harbor during the fiscal year consisted of necessary repairs.

The channel is in good condition, with an available water-way of 13 feet.

Under the appropriation of August 14, 1876, two cribs will be added to the south pier. The work is under contract. The end of the pier will then rest in 20 feet of water, and no appropriation is asked for the fiscal year 1878-'79.

July 1, 1876, amount available	$6,528 62	
Amount appropriated by act approved August 14, 1876	15,000 00	
		$21,528 62
July 1, 1877, amount expended during fiscal year	3,703 16	
July 1, 1877, outstanding liabilities	8,543 98	
		12,247 14
July 1, 1877, amount available		9,281 48
Amount (estimated) required for completion of existing project		8,898 04

(See Appendix B B 7.)

8. *Grand Haven Harbor, Michigan.*—Both pier-heads were riprapped last fall and some defective places in piers and revetments repaired, leaving them in good condition for the winter.

The whole channel-way between the piers is now available for any class vessel plying the lakes.

With the appropriation of $15,000 of act of August 14, 1876, the north pier will be extended 150 feet. The work is progressing under contract.

Upon completion the pier-heads will be nearly abreast. As a further extension of the north pier may be deferred for the present, the estimates therefor are omitted.

Fourteen thousand four hundred dollars will be required to continue the revetment into the bend of the river, and $3,640 for repairs. Nine thousand six hundred and eight dollars and ninety-six cents is also required to renew the superstructure over 800 feet of south pier. Total, $27,648.96.

July 1, 1876, amount available	$4,774 23	
Amount appropriated by act approved August 14, 1876	15,000 00	
		$19,774 23
July 1, 1877, amount expended during fiscal year	3,506 12	
July 1, 1877, outstanding liabilities	13,264 72	
		16,770 84
July 1, 1877, amount available		3,003 39
Amount (estimated) required for completion of existing project		44,148 96
Amount that can be profitably expended in fiscal year ending June 30, 1879.		27,600 00

(See Appendix B B 8.)

9. *Black Lake Harbor, Michigan.*—The encroachments of sand through the revetment and by the mouth of the harbor left but 7 feet water in the channel last fall. The funds on hand were not sufficient for the extended repairs necessary, so the pier-heads were secured and the work left for the winter. This spring we find but about 6½ feet water between the piers for quite a distance.

Under the appropriation of August 14, 1876, the whole work will be put in complete order, with revetments impervious to the passage of sand. The channel will be dredged out to 11 feet water and south pier extended 50 feet. The work is now progressing under contract.

Both piers should be extended 200 feet to secure a channel-way of 12 feet, which is proportionate to the harbor's commercial importance. Thirty-two thousand dollars will be needed for this purpose, and can be profitably expended during the next season.

July 1, 1876, amount available	$4,281 65	
Amount appropriated by act approved August 14, 1876	15,000 00	
		$19,281 65
July 1, 1877, amount expended during fiscal year	1,608 32	
July 1, 1877, outstanding liabilities	7,191 18	
		8,799 50
July 1, 1877, amount available		10,482 15
Amount (estimated) required for completion of existing project		32,000 00
Amount that can be profitably expended in fiscal year ending July 30, 1879..		32,000 00

(See Appendix B B 9.)

10. *Saugatuck Harbor, Michigan.*—One-half the appropriation of August 14, 1876, was made available last fall, and all necessary repairs were made to the piers to secure them for the winter. The balance of the appropriation was made available this spring, and during June partially expended in refilling the piers and revetments and decking the south pier-head.

Thirty-eight thousand four hundred and fifty-eight dollars and seventy-four cents has been estimated as necessary to complete the existing project, $10,000 of which can be profitably expended next season in extending the north pier.

July 1, 1876, amount available	$244 86	
Amount appropriated by act approved August 14, 1876	3,000 00	
		$3,244 86
July 1, 1877, amount expended during fiscal year	1,705 82	
July 1, 1877, outstanding liabilities	1,111 83	
		2,817 65
July 1, 1877, amount available		427 21
Amount (estimated) required for completion of existing project		38,458 74
Amount that can be profitably expended in fiscal year ending June 30, 1879..		10,000 00

(See Appendix B B 10.)

11. *South Haven Harbor, Michigan.*—Of the last appropriation for this work ($10,000) there was allotted late in the season $3,500 for absolutely necessary repairs. The pier-heads were secured, and now stand in good condition.

During the winter a breach of 90 feet was forced through the south revetment, near the shore-line, through which the sand entered and filled the channel between the piers, so as to leave but 6½ feet of water.

The balance now available will be used this season in closing this gap and dredging the channel to about 11 feet. The work is being done with the Government machinery and hired labor.

The recommendations of last year are renewed: 250 feet revetment, north side, estimated cost $12,000, and the extension of both piers 300 feet, estimated cost $60,000, of which $25,000 can be profitably expended during the next working season.

July 1, 1876, amount available	$90 27	
Amount appropriated by act approved August 14, 1876	10,000 00	
		$10,090 27
July 1, 1877, amount expended during fiscal year	4,736 05	
July 1, 1877, outstanding liabilities	1,439 30	
		6,175 35
July 1, 1877, amount available		3,914 92
Amount, (estimated) required for completion of existing project		72,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		25,000 00

(See Appendix B B 11.)

12. *Saint Joseph Harbor and River, Michigan.*—A part of the appropriation of August 14, 1876, was expended in needed repairs, and a contract made to extend the north pier 50 feet.

As a considerable outlay is necessary to put the work in complete order, the balance on hand will be applied accordingly this season.

The end crib of north pier was carried away in March, 1876; its place was supplied with a new crib in June last.

The water in the channel holds to a good depth.

The recommendations and estimates of last year are renewed, viz: to extend the north pier to 16 feet water, estimated to cost $16,261.71; and $15,000 will be required for the improvement in the river at the mouth of canal leading to Benton Harbor.

July 1, 1876, amount available	$365 40	
Amount appropriated by act approved August 14, 1876	12,000 00	
		$12,365 40
July 1, 1877, amount expended during fiscal year	4,309 36	
July 1, 1877, outstanding liabilities	1,048 74	
		5,358 10
July 1, 1877, amount available		7,007 30
Amount (estimated) required for completion of existing project		31,261 71
Amount that can be profitably expended in fiscal year ending June 30, 1879		31,000 00

(See Appendix B B 12.)

ENLARGEMENT OF SAINT MARY'S FALLS CANAL—CONSTRUCTION OF HARBOR OF REFUGE ON LAKE HURON—IMPROVEMENT OF THE HARBORS OF AU SABLE AND THUNDER BAY; OF DETROIT RIVER AND SAINT CLAIR RIVER AT MOUTH OF BLACK RIVER.

Officer in charge, Maj. G. Weitzel, Corps of Engineers, with Capt. A. N. Lee, Corps of Engineers, under his immediate orders.

1. *Improvement of Saint Mary's Falls Canal, Michigan.*—During the year 54,637 cubic feet of cut stone, about one-fifth of all required for the new

locks, have been delivered; 113,373 cubic feet of masonry, about one-sixth of all required, laid in the walls. The arm between the south pier at the foot of the new locks and the shore-line was filled in to the level of the shore, and the banks of the canal near its lower end were raised.

The officer in charge is of opinion that for an economical and rapid prosecution of this work the sum of $300,000 should be appropriated for the fiscal year ending June 30, 1877.

July 1, 1876, amount available	$397,227 93
Amount appropriated by act approved August 14, 1876	130,000 00
	527,227 93
July 1, 1877, amount expended during fiscal year	108,213 84
July 1, 1877, amount available	419,014 09
Amount (estimated) required for completion of existing project	570,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	300,000 00

(See Appendix C C 1.)

2. *Construction of Harbor of Refuge, Lake Huron, Michigan.*—During the past year 9 cribs 65 feet long were placed and filled in continuation of the east or sea arm of the breakwater. Contract was entered into to build 3 more of these cribs, and to place the superstructure on these three and thirteen others which are already in place. This contract will be completed during the present season, and there will be 2,310 linear feet of the sea-arm in place. A contract for the removal of the wreck of the "City of Buffalo" and several dangerous bowlders has also been entered into, and will undoubtedly be completed during the present season.

When these contracts are all executed there will remain only 1,690 linear feet of the sea-arm of the breakwater to construct in order to complete this improvement. If it is decided to close the opening which has been left in the shore-arm, it will cost altogether, it is estimated, $330,000 to complete this improvement, and it is recommended by the officer in charge, for the sake of economy, that this sum be appropriated at once.

July 1, 1876, amount available	$96,698 74
Amount appropriated by act approved August 14, 1876	75,000 00
	171,698 74
July 1, 1877, amount expended during fiscal year	95,373 94
July 1, 1877, amount available	76,324 80
Amount (estimated) required for completion of existing project	330,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	330,000 00

(See Appendix C C 2.)

3. *Improvement of Au Sable River Harbor, Michigan.*—Nothing has been done on this work during the year, and no appropriation is asked for.

July 1, 1876, amount available	$1,426 62
Amount appropriated by act approved August 14, 1876	1,000 00
	2,426 62
July 1, 1877, amount expended during fiscal year	313 13
July 1, 1877, amount available	2,113 49

(See Appendix C C 3.)

4. *Improvement of Thunder Bay Harbor, Michigan.*—This work, which consists in dredging to get 13 feet water at the mouth of Thunder Bay

River, will be placed under contract and completed during the present season. No further appropriation will be required.

Amount appropriated by act approved August 14, 1876	$4,500 00
July 1, 1877, amount available	4,500 00

(See Appendix C C 4.)

5. *Improvement of the Saint Clair River, at the mouth of Black River, Michigan.*—This work was closed on September 30, 1876, for want of funds. In order to complete the improvement it is necessary to dredge about 4,000 cubic yards more, and it is recommended by the officer in charge that the sum of $1,500 be appropriated for this purpose for the fiscal year ending June 30, 1879.

July 1, 1876, amount available	$5,390 52
July 1, 1877, amount expended during fiscal year	5,390 52
Amount (estimated) required for completion of existing project	1,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	1,500 00

(See Appendix C C 5.)

6. *Improvement of Detroit River, Michigan.*—This work was begun in the latter part of September, 1876, at the shallowest portion of the Lime-Kilns Crossing, directly in front of the Canada Southern Railroad dock, and 2,632 cubic yards of rock excavated, when the funds were exhausted. The work which has been done leaves this spot in a more dangerous condition than it was before, because it has of course left high rock projections in the edges of the excavation.

The officer in charge believes that $200,000 additional will give a channel 300 feet wide and 20 feet deep across this dangerous shoal, if the money is appropriated at one time, and he recommends that this be done.

July 1, 1876, amount available	$21,446 10
July 1, 1877, amount expended during fiscal year	21,446 10
Amount (estimated) required for completion of existing project	200,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	200,000 00

(See Appendix C C 6.)

REPAIR AND PRESERVATION OF SAINT CLAIR FLATS CANAL—IMPROVEMENT OF SAGINAW RIVER AND CHEBOYGAN HARBOR, MICHIGAN.

Officer in charge, Maj. Franklin Harwood, Corps of Engineers, since February 27, 1877.

1. *Saint Clair Flats Canal.*—Minor repairs have been made on the canal banks. Early in May, 1877, extensive damage was done to the banks by vessels using the canal as a harbor of refuge from running ice. This damage, to the extent of $2,000 to $4,000, will be repaired during the summer of 1877, and the canal placed in thorough order.

Measures have been taken, under provisions of section 3, appropriation bill, approved August 14, 1876, to prosecute persons who have damaged the canal banks.

As the present appropriation will be nearly exhausted in repairing these damages, an appropriation of $5,000 is asked for repair and preservation of the canal.

July 1, 1876, amount available	$11,208 14
July 1, 1877, amount expended during fiscal year	5,359 16
July 1, 1877, amount available	5,848 98
Amount (estimated) required for preservation of existing work	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	5,000 00

(See Appendix D D 1.)

2. *Improvement of Saginaw River, Michigan.*—Work was resumed on the pile revetment opposite Carrolton Bar May 31, 1877, and at the close of the fiscal year good progress had been made of work. It is expected, during the working season of 1877, to add about 500 feet to this revetment, and improve the channel abreast of the extension by dredging; also, to build a bulkhead 235 feet long, from the head of the revetment across to Hoyt's Mill site, to cut off the flow of the river behind the revetment, which is retarding the improvement at present. The estimates of last year are renewed.

July 1, 1876, amount available	$1,184 13
Amount appropriated by act approved August 14, 1876	11,000 00
	12,184 13
July 1, 1877, amount expended during fiscal year	1,782 12
July 1, 1877, amount available	10,402 01
Amount (estimated) required for completion of existing project	50,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	50,000 00

(See Appendix D D 2.)

3. *Improvement of Cheboygan Harbor, Michigan.*—Nothing has been done on this work during the year, the appropriation of $10,000 of August 14, 1876, having been withheld until early in May of the present year. It will be expended during the present working season in continuing the dredging as heretofore projected. An appropriation of $20,000 is recommended by the officer in charge to complete the channel to a width of 200 feet, with 13 feet depth of water, which sum can be profitably expended in one working season, completing the project for the time being.

July 1, 1876, amount available	$262 44
Amount appropriated by act approved August 14, 1876	10,000 00
	10,262 44
July 1, 1877, amount expended during fiscal year	341 67
July 1, 1877, amount available	9,920 77
Amount (estimated) required for completion of existing project	20,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	20,000 00

(See Appendix D D 3.)

HARBORS ON LAKE ERIE WEST OF CLEVELAND.

Officer in charge, Maj. N. Michler, Corps of Engineers, since December 1, 1876, previous to which time in charge of Lieut. Col. C. E. Blunt, Corps of Engineers.

1. *Monroe Harbor, Michigan.*—Work was commenced the last of May, and consisted in partially renewing the revetment of the sides of the ship-canal at Raisin River; 3,260 feet in all need renewal and some slight repairs to piers are necessary.

July 1, 1876, amount available	$40 54
Amount appropriated by act approved August 14, 1876	5,000 00
	5,040 54
July 1, 1877, amount expended during fiscal year	548 10
July 1, 1877, amount available	4,492 44
Amount (estimated) required for completion of existing project	11,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	11,000 00

(See Appendix E E 1.)

2. *Toledo Harbor, Ohio.*—The work of dredging the channel through Maumee Bay was resumed on the 30th of April, in accordance with the plan of the board of engineer officers, approved in 1875, and was principally confined to the north or outer reach near Turtle Island. Forty-four thousand five hundred and forty-one cubic yards have been removed by dredging. The work will be continued in the same manner during the present season. The projected dimensions of the channel are 250 feet in width at top, with a depth of 15 feet.

July 1, 1876, amount available	$4,180 67
Amount appropriated by act approved August 14, 1876	60,000 00
	64,180 67
July 1, 1877, amount expended during fiscal year	13,411 32
July 1, 1877, amount available	50,769 35
Amount (estimated) required for completion of existing project	140,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	140,000 00

(See Appendix E E 2.)

3. *Port Clinton Harbor, Ohio.*—During the last days of June the work of constructing a new pier or revetment, the east one, was commenced, but only about 800 feet can be completed before the present appropriation becomes exhausted. When additional appropriation is made it is proposed to extend the two piers further into the lake, so as to confine the flow of Portage River between them, and also to partially dredge a cut throughout the entire length, as it is expected that the strong current will open a channel of suitable dimensions to meet the needs of commerce.

July 1, 1876, amount available	$16 20
Amount appropriated by act approved August 14, 1876	5,000 00
	5,016 20
July 1, 1877, amount expended during fiscal year	86 27
July 1, 1877, amount available	4,929 93
Amount (estimated) required for completion of existing project	112,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	20,000 00

(See Appendix E E 3.)

4. *Sandusky City Harbor, Ohio.*—The work of dredging the west channel of Sandusky Bay was renewed on the 3d of May, being confined chiefly to the outer reach near Cedar Point, and to widening the sweeps of the several elbows. The quantity of material dredged and removed was 26,617 cubic yards. After the completion of operations in the cuts between the 12 and 15 foot curves, it is proposed during the present year to extend the channel towards the city front. The dimensions are in width 200 feet, and in depth 15 feet.

July 1, 1876, amount available	$106 77
Amount appropriated by act approved August 14, 1876	25,000 00
	25,106 77
July 1, 1877, amount expended during fiscal year	3,334 86
July 1, 1877, amount available	21,771 91
Amount (estimated) required for completion of existing project	105,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	55,000 00

(See Appendix E E 4.)

5. *Huron Harbor, Ohio.*—There was no work done during the last fiscal year, as there was but a small balance of the appropriation available.

As soon as funds are available some repairs to the piers will require attention.

July 1, 1876, amount available	$189 17
July 1, 1877, amount available	189 17
Amount (estimated) required for repairs	1,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	1,000 00

(See Appendix E E 5.)

6. *Vermillion Harbor, Ohio.*—In consequence of the appropriation of August 14, 1876, not having been made available until toward the close of the fiscal year, the work upon this improvement was not renewed. As soon as arrangements can be made, it will be forwarded as far toward completion as the small amount of funds available will permit. The works consist in the blasting and removal of rock, and the dredging of sand from the channel of the artificial harbor; also, in slight repairs to piers.

July 1, 1876, amount available	$125 45
Amount appropriated by act approved August 14, 1876	5,000 00
	5,125 45
July 1, 1877, amount expended during fiscal year	1,011 60
July 1, 1877, amount available	4,113 85
Amount (estimated) required for completion of existing project	9,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	9,000 00

(See Appendix E E 6.)

7. *Black River Harbor, Ohio.*—During the fiscal year, by direction of my predecessor, very considerable repairs were made to the piers, both of which had been damaged during the previous spring by severe gales. A cut made by the lake at the shore end of one of them was also closed, to prevent the channel from being filled up by sand. The last appropriation was nearly exhausted by these necessary expenditures. As soon as funds become available additional repairs will receive attention.

July 1, 1876, amount available	$56 41
Amount appropriated by act approved August 14, 1876	6,000 00
	6,056 41
July 1, 1877, amount expended during fiscal year	6,003 52
July 1, 1877, amount available	52 89

(See Appendix E E 7.)

HARBORS ON LAKE ERIE EAST OF BLACK RIVER.

Officer in charge, Lieut. Col. C. E. Blunt, Corps of Engineers.

1. *Breakwater at Cleveland, Ohio.*—The pile-pier forming the shore end was completed during the year. Three cribs, each 50 feet long, have also been sunk, and the superstructure upon them partially built. It is expected to extend the work 300 feet with the balance of the appropriation still available. Contracts have been made for this extension.

For further continuance of the breakwater and for incidental repairs of the work an appropriation of $200,000 is asked.

July 1, 1876, amount available	$33,426 26
Amount appropriated by act approved August 14, 1876	50,000 00
	83,426 26
July 1, 1877, amount expended during fiscal year	48,152 98
July 1, 1877, amount available	35,273 28
Amount (estimated) required for completion of existing project	1,700,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879, for continuing the breakwater and for incidental repairs of harbor.	200,000 00

(See Appendix F F 1.)

2. *Repairs of East Pier at Cleveland, Ohio.*—These repairs are in progress and will be completed in July. This portion of the pier will hereafter be in charge of the Cleveland and Pittsburgh Railroad Company, by special agreement made through a commission appointed by the President. As the company will be responsible for its future condition no additional appropriation is required for this part of the construction.

The east and west piers proper, still under control of the United States, were repaired in 1874-'75.

Amount appropriated by act approved August 14, 1876	$8,000 00
July 1, 1877, amount expended during fiscal year	4,495 75
July 1, 1877, amount available	3,504 25

(See Appendix F F 2.)

3. *Fairport Harbor, Ohio.*—The amount available during the year has been expended in partially rebuilding the old west pier, in building a catch-sand fence to prevent the blowing of sand into the channel, and in removing part of the sand which had blown in.

For further pier-repairs, removal of entrance-bar and sand remaining in the upper channel, an appropriation of $5,000 is required.

The east pier is 104 feet shorter than the west. It may become necessary to extend it, but no estimate for this is made at present.

July 1, 1876, amount available	$2,421 43
Amount appropriated by act approved August 14, 1876	5,000 00
	7,421 43
July 1, 1877, amount expended during fiscal year	7,415 95
July 1, 1877, amount available	5 48
Amount (estimated) required for completion of existing project	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	5,000 00

(See Appendix F F 3.)

4. *Ashtabula Harbor, Ohio.*—Damages to the west pier by a gale were repaired during the fall of 1876. A sand-bar at the entrance, also caused by a gale, was removed about the same time. The appropriation of August 14, 1876, which was not available until this spring, will be applied this season in building a west pier-head and in removing bars. For repairs of the old piers, and for further dredging which will be needed next year, the appropriation of $5,000 is required.

July 1, 1876, amount available	$14,623 85
Amount appropriated by act approved August 14, 1876	5,000 00
	19,623 85
July 1, 1877, amount expended during fiscal year	13,039 69
July 1, 1877, amount available	6,584 16
Amount (estimated) required for completion of existing project	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	5,000 00

(See Appendix F F 4.)

5. *Conneaut Harbor, Ohio.*—Some minor repairs of piers were made during the year, and the harbor is now in good condition.

No appropriation is required.

July 1, 1876, amount available	$68 45
July 1, 1877, amount expended during fiscal year	14 95
July 1, 1877, amount available	53 50

(See Appendix F F 5.)

6. *Erie Harbor, Pennsylvania.*—During the year 1,461 feet of catch-sand fence for the protection of the peninsula have been built, making the entire length 5,997 feet. Four hundred and fifteen feet of the old north pier have been rebuilt and 28,594 cubic yards of sand removed from the channel.

Additional funds will be needed for similar work, and for extending the south pier. The total amount of the revised estimate is $119,000. Postponing the south pier extension, the sum required for the next fiscal year is $41,000.

July 1, 1876, amount available	$25,011 06	
Amount appropriated by act approved August 14, 1876	40,000 00	
		$65,011 06
July 1, 1877, amount expended during fiscal year	36,300 98	
July 1, 1877, outstanding liabilities	188 22	
		36,489 20
July 1, 1877, amount available		28,521 86
Amount (estimated) required for completion of existing project		119,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		41,000 00

(See Appendix F F 6.)

7. *Dunkirk Harbor, New York.*—The blasting and dredging in the channel has been completed, exhausting the old appropriation of 1875.

Damages to the west pier, caused by a gale in December, 1876, were repaired immediately after they occurred, with an allotment of $2,500 from the appropriation of August 14, 1876.

The balance ($15,000) of that appropriation will be expended in extending the breakwater.

An appropriation of $31,000 is asked to complete the work for the present.

July 1, 1876, amount available	$22,550 74
Amount appropriated by act approved August 14, 1876	18,000 00
	40,550 74
July 1, 1877, amount expended during fiscal year	24,846 12
July 1, 1877, amount available	15,704 62
Amount (estimated) required for completion of existing project	31,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	31,000 00

(See Appendix F F 7.)

8. *Buffalo Harbor, New York.*—The results of last year's expenditure have been as follows: Extension of the completed breakwater 150 feet, (3 cribs.) Repairs of the old work, and of the old channel piers. Refilling the pile-pier with stone to replace that lost by settlement.

The balance now in the Treasury ($40,000) will be expended in further breakwater extension, for which purpose, also, a new appropriation of $200,000 is recommended by the officer in charge.

July 1, 1876, amount available	$10 04	
Amount appropriated by act approved August 14, 1876	85,000 00	
		$85,010 04
July 1, 1877, amount expended during fiscal year	44,994 17	
July 1, 1877, outstanding liabilities	3,493 50	
		48,487 67
July 1, 1877, amount available		36,522 37
Amount (estimated) required for completion of existing project		1,815,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		200,000 00

(See Appendix F F 8.)

HARBORS ON LAKE ONTARIO AND THE RIVER SAINT LAWRENCE.

Officer in charge, Maj. Walter McFarland, Corps of Engineers.

1. *Wilson Harbor, New York.*—The old inner part of the west pier, built many years ago by private means, was breached by the sea in the fall of the year, and during the winter the entrance to the harbor was entirely closed by the washing in of sand and gravel.

The appropriation of August 14, 1876, will be applied to the re-opening of this harbor.

July 1, 1876, amount available	$166 64
Amount appropriated by act approved August 14, 1876	10,000 00
	10,166 64
July 1, 1877, amount expended during fiscal year	148 19
July 1, 1877, amount available	10,018 45
Amount (estimated) required for completion of existing project	80,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	80,000 00

(See Appendix G G 1.)

2. *Alcott Harbor, New York.*—Nothing has been done at this harbor during the year, no funds being available.

July 1, 1876, amount available	$3,484 20
July 1, 1877, amount expended during fiscal year	3,421 00
July 1, 1877, amount available	63 20
Amount (estimated) required for completion of existing project	10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	10,000 00

(See Appendix G G 2.)

3. *Oak Orchard Harbor, New York.*—Nothing has been done at this harbor during the year, there being no funds available.

The appropriation of August 14, 1876, will be applied to the repair of the two piers.

July 1, 1876, amount available	$234 64
Amount appropriated by act approved August 14, 1876	2,000 00
	2,234 64
July 1, 1877, amount expended during fiscal year	233 12
July 1, 1877, amount available	2,001 52
Amount (estimated) required for completion of existing project	4,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	4,000 00

(See Appendix G G 3.)

4. *Charlotte Harbor, New York.*—Nothing has been done here beyond the removal of a few decayed plank, and the replacing of stone which had been washed out of the pier.

The improvement is completed and probably no more money will be required except for repairs.

July 1, 1876, amount available	$597 86
July 1, 1877, amount expended during fiscal year	575 32
July 1, 1877, amount available	22 54
Amount that can be profitably expended in fiscal year ending June 30, 1879, in repairs	1,000 00

(See Appendix G G 4.)

5. *Pultneyville Harbor, New York.*—Nothing has been done here during the year, owing to want of funds.

The appropriation of August 14, 1876, will be applied to repair of the west pier and extension, landward, of the east pier.

July 1, 1876, amount available	$126 56
Amount appropriated by act approved August 14, 1876	3,000 00
	3,126 56
July 1, 1877, amount expended during fiscal year	87 12
July 1, 1877, amount available	3,039 44
Amount (estimated) required for completion of existing project	18,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	18,000 00

(See Appendix G G 5.)

6. *Great Sodus Harbor, New York.*—Nothing has been done here excepting a few repairs to the sand-fence and piers.

The appropriation of August 14, 1876, will be applied to the construction of a new sand-fence and further repairs of piers.

July 1, 1876, amount available	$2,221 12
Amount appropriated by act approved August 14, 1876	5,000 00
	7,221 12
July 1, 1877, amount expended during fiscal year	749 03
July 1, 1877, amount available	6,472 09
Amount (estimated) required for completion of existing project	10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	10,000 00

(See Appendix G G 6.)

7. *Little Sodus Harbor, New York.*—Nothing has been done here, except repairing a breach 70 feet long in the west beach, made by the sea.

The appropriation of August 14, 1876, will be applied to the repair of the west pier, and the extension, landward, of the inner end of the east pier.

July 1, 1876, amount available	$1,289 96
Amount appropriated by act approved August 14, 1876	5,000 00
	6,289 96
July 1, 1877, amount expended during fiscal year	433 39
July 1, 1877, amount available	5,856 57
Amount (estimated) required for completion of existing project	12,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	12,000 00

(See Appendix G G 7.)

8. *Oswego Harbor, New York.*—Two hundred and ten feet of the superstructure of the new breakwater have been built, and a counterfort has been placed in rear of the exposed end.

Very extensive repairs have been made to this structure, where it had settled and was damaged by the action of the sea, as well as to the old breakwater, which had also been badly damaged by storms.

The new breakwater is now 3,692 feet long, and is yet to be extended about 2,000 feet, according to the original project.

The balance of the last appropriation will be applied to the extension of the new breakwater, whose length will probably be increased this year between 400 and 500 feet.

July 1, 1876, amount available	$9,058 49
Amount appropriated by act approved August 14, 1876	90,000 00
	99,058 49
July 1, 1877, amount expended during fiscal year	40,588 48
July 1, 1877, amount available	58,470 01
Amount (estimated) required for completion of existing project	557,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	300,000 00

(See Appendix G G 8.)

9. *Ogdensburgh Harbor, New York.*—Nothing has been done here this year, owing to want of funds.

The original scheme of improvement provided for the dredging of certain parts of the channel and harbor, and for the construction of pile-piering to prevent the waters of the Oswegatchie from wasting their force by spreading over the shoal which lies in front of the city.

The dredging has been essentially completed, and there appears to be no present necessity for constructing the proposed pile-piering, the estimated cost of which is about $70,000.

July 1, 1876, amount available	$59 10
July 1, 1877, amount expended during fiscal year	44 02
July 1, 1877, amount available	15 08
Amount (estimated) required for completion of existing project	70,000 00

(See Appendix G G 9.)

10. *Waddington Harbor, New York.*—This improvement has been finished in accordance with the original scheme, and nothing more is needed for it. No work has been done upon it during the past year.

July 1, 1876, amount available	$42 72
July 1, 1877, amount expended during fiscal year	42 72

(See Appendix G G 10.)

PACIFIC COAST.

IMPROVEMENT OF OAKLAND HARBOR—CONSTRUCTION OF BREAKWATER AT WILMINGTON—REMOVAL OF RINCON ROCK, SAN FRANCISCO HARBOR, AND IMPROVEMENT OF SACRAMENTO AND FEATHER RIVERS.

Officer in charge, Maj. G. H. Mendell, Corps of Engineers.

1. *Improvement of Oakland Harbor, California.*—The south jetty was extended 400 feet during the year, requiring 2,335 tons of stone.

A channel 200 feet wide, 10 feet deep at low water, and 6,300 feet long, was dredged during the year, except that for 900 feet the width is only 100 feet. The remainder of the dredging at present contemplated is under contract at 35 cents per yard. The contract went in force on June 1, and will probably be completed in July.

Previous to June 1, and subsequent to September 12, 1876, the dredging was executed under a temporary arrangement, at a stipulated price of 24 cents a yard. From July 1 to September 12 the dredging was done under a contract at the same price. Owing to want of progress the work was taken out of the contractor's hands. Since June 1 the price has been 35 cents per yard.

A contract for 20,000 tons of stone was made in May at $1.19 per ton. During June 2,335 tons of stone were delivered.

These operations will require all the money available at present.

The completion of the training-walls, and measures looking to an increase of the tidal prism, will have attention when further appropriations become available.

July 1, 1876, amount available	$17,157 50	
Amount appropriated by act approved August 14, 1876	75,000 00	
		$122,157 50
July 1, 1877, amount expended during fiscal year	59,192 26	
July 1, 1877, outstanding liabilities	1,062 56	
		60,254 82
July 1, 1877, amount available		61,902 68
Amount (estimated) required for completion of existing project		1,539,529 20
Amount that can be profitably expended in fiscal year ending June 30, 1879		200,000 00

(See Appendix H H 1.)

2. *Improvement of Wilmington Harbor, California.*—The channel has steadily improved both in width and depth during the year, without the aid of dredging. There is now a good channel carrying 8 feet at mean low-water. When the improvement was commenced there was no channel, but an irregular bottom with 1 foot and up to 2 feet of water at mean low tide.

The contractor removed from the reef during the year 4,601 yards of stone and 4,561 yards of clay. He also dredged 2,273 yards of sand, partly from the reef.

The stone and clay taken from the reef were used to extend the west training-wall for a distance of 800 feet.

Three thousand two hundred and forty-nine tons of stone were purchased and applied to the training-wall; to a portion of the main jetty; to brush-work, and to the construction of a groin on the seaward side of the main work.

About 6,400 yards of sand were collected on the main line by aid of brush.

Operations on the harbor were suspended in February on account of the exhaustion of the appropriation. A keeper is in charge of the property.

The cut in the reef is now 150 feet in width. It ought to be made 200 feet. Its depth is now 12 feet at mean low-water, which is 10 feet at lowest tide. It could be profitably deepened 2 feet. The completion of the west training-wall and raising of the stone line on the main jetty are also points that will receive attention when additional appropriation is made.

It is the custom for all coasting sail-vessels to enter the harbor; 29 vessels entered in November, 1876; 2 of these drew 14 feet, and 20 drew 13 feet.

July 1, 1876, amount available	$40,268 15
July 1, 1877, amount expended during fiscal year	39,324 73
July 1, 1877, amount available	943 42
Amount (estimated) required for completion of existing project	100,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	50,000 00

(See Appendix H H 2.)

3. *Removal of Rincon Rock, San Francisco Harbor, California.*—The work was accepted in an unfinished state, in accordance with the wishes of the State harbor commissioners, within whose jurisdiction the rock lay.

A survey made in the latter part of July showed that 4,357 yards had been removed. The contents of the rock required to be removed by

the contract was 4,745 cubic yards. The contractor was paid $39,483.88 for his work.

The least depth of water on the rock is 21¾ feet at mean low-water.

July 1, 1876, amount available	$24,380 27
July 1, 1877, amount expended during fiscal year	20,157 75
July 1, 1877, amount available	4,222 52

(See Appendix H H 3.)

4. *Improvement of Sacramento and Feather Rivers, California.*—No operations for the improvement of these rivers were carried on in the past year, as no appropriation has been made since 1875.

An examination of Georgiana Slough was made in June, 1877, by Lieut. A. H. Payson, Corp of Engineers.

Each winter throws a considerable number of snags into the river, which, with a few bars here and there, form serious obstructions to the navigation of these waters.

July 1, 1876, amount available	$259 88
July 1, 1877, amount expended during fiscal year	16 63
July 1, 1877, amount available	243 25
Amount that can be profitably expended in fiscal year ending June 30, 1879.	20,000 00

(See Appendix H H 4.)

IMPROVEMENT OF THE HARBOR OF SAN DIEGO—IMPROVEMENT OF SAN JOAQUIN RIVER, CALIFORNIA.

Officer in charge, Lieut. Col. C. S. Stewart, Corps of Engineers, with the late Lieut. J. H. Weeden, Corps of Engineers, under his immediate orders to January 29, 1877.

1. *San Diego Harbor, California.*—The San Diego River formerly emptied into False Bay. Many years since, during a freshet, its course was changed, and its waters, pouring into the harbor, deposited into it more or less sand, to its great injury. To prevent further damage, it was determined to turn the river back into its former channel. This has been accomplished by the excavation of an artificial channel and the embankment of a levee, faced with stone, which were completed by the contractors in November last.

The whole length of the levee and artificial channel, as completed, is reported to be 7,734.6 feet; whole amount of earth excavated and used for embankment, 91,628.5 cubic yards, and of stone in place, 13,454.6 cubic yards.

The cost of the works, finished, has been	$79,798 72
The amount appropriated therefor	80,000 00

During the past winter there have been no floods in the river to test the works. Their value and what may be the cost of yearly repairs can only be ascertained by future experience.

The benefit to commerce and navigation from this work will be the preservation of the only good land-locked harbor on the Pacific coast south of San Francisco so long as the San Diego River shall be kept from emptying into it.

July 1, 1876, amount available	$74,182 49
July 1, 1877, amount expended during fiscal year	73,981 21
July 1, 1877, amount available	201 28

(See Appendix I I 1.)

2. *Improvement of San Joaquin River, California.*—The appropriation of $20,000 for this improvement, in the river and harbor act of August 14, 1876, was made available in March last.

It is proposed to survey that portion of the river below Stockton, where navigation is most impeded, so soon as the low stage of water is attained, and, if necessary, to contract in the usual manner for the removal of the shoals by dredging.

Amount appropriated by act approved August 14, 1876	$20,000 00
July 1, 1877, amount expended during fiscal year	6 80
July 1, 1877, amount available	19,993 20

(See Appendix I I 2.)

IMPROVEMENT OF RIVERS IN OREGON AND IN WASHINGTON TERRITORY.

Officer in charge, Maj. John M. Wilson, Corps of Engineers.

1. *Improvement of Lower Willamette and Columbia Rivers, Oregon.*—Operations during the fiscal year have consisted of dredging at the mouth of the Willamette at Post-Office Bar, and Swan Island Bar, Willamette River; 21,285 cubic yards of mud, sand, gravel, &c., having been removed.

Extensive surveys were made of the Willamette River from Portland to its mouth, the Willamette Slough, Saint Helen's and Snag Island Bars.

During the present season it is proposed to continue dredging the channel over the bars in the Willamette River, and to make surveys at Swan Island Bar, Willamette River, and Saint Helen's Bar, Columbia River.

A plan for the permanent improvement of these rivers has been submitted by the Board of Engineers for the Pacific Coast, and approved.

July 1, 1876, amount available	$9,093 24	
Amount appropriated by act approved August 14, 1876	20,000 00	
		$29,093 24
July 1, 1877, amount expended during fiscal year		10,508 70
July 1, 1877, amount available		18,584 54
Amount (estimated) required for completion of existing project		298,974 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		150,000 00

(See Appendix J J 1.)

2. *Improvement of Upper Willamette River, Oregon.*—Operations during the fiscal year have consisted of the removal of snags, stumps, rocks, &c., and the construction of wing-dams. Four thousand seven hundred and thirty-two feet of wing-dams have been built, 71¼ cubic yards of rock excavated, and 901 snags, stumps, &c., removed. A new snag-boat has been built.

During the present season it is proposed to construct about 4,000 feet of wing-dams at points where they are most necessary, and to continue the removal of snags from the channel. The engineer in charge recommends the construction of two steam snag-boats, with scrapers and pile-drivers attached, for keeping the river open during low-water season.

July 1, 1876, amount available	$8,038 25	
Amount appropriated by act approved August 14, 1876	20,000 00	
		$28,038 25
July 1, 1877, amount expended during fiscal year	13,796 47	
July 1, 1877, outstanding liabilities	2,157 45	
		15,953 92
July 1, 1877, amount available		12,084 33
Amount (estimated) required for completion of existing project		80,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		50,000 00

(See Appendix J J 2.)

3. *Improvement of the Upper Columbia and Snake Rivers, Oregon, and Washington Territory.*—Operations during the fiscal year were carried on from November, 1876, until March, 1877, removing rock from the channel at Squally Hook, Owyhee, and Umatilla Rapids, in the Columbia River, and Pine Tree Rapid, in the Snake; 745.14 cubic yards of rock in all were removed, and the channel greatly improved, particularly at Pine Tree Rapid, from which 477.51 cubic yards of rock were taken.

During the coming winter it is proposed to continue the work by removing 150 yards of rock from Umatilla Rapid, Columbia River.

July 1, 1876, amount available	$16,007 10	
Amount appropriated by act approved August 14, 1876	15,000 00	
		$31,007 00
July 1, 1877, amount expended during fiscal year	25,257 01	
July 1, 1877, outstanding liabilities	155 00	
		25,412 01
July 1, 1877, amount available		5,595 09
Amount (estimated) required for completion of existing project		132,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		66,000 00

(See Appendix J J 3.)

4. *Construction of canal around the Cascades of Columbia River, Oregon.*—A survey has been made during the fiscal year of the country on the Oregon side of the river, bordering on the Cascades; a careful reconnaissance on the Washington Territory side, and a hydrographic survey of the river above and below the falls.

The engineer in charge has submitted plans and estimates for a canal, which have been referred to the Board of Engineers for the Pacific Coast for examination.

Amount appropriated by act approved August 14, 1876	$90,000 00
July 1, 1877, amount expended during fiscal year	4,616 65
July 1, 1877, amount available	85,383 35
Amount (estimated) required for completion of existing project	1,459,136 40
Amount that can be profitably expended in fiscal year ending June 30, 1879	500,000 00

(See Appendix J J 4.)

EXAMINATIONS WITH A VIEW TO ESTABLISHING A HARBOR OF REFUGE ON THE PACIFIC COAST.

To comply with a resolution of the House of Representatives of April 27, 1876, asking for an examination of the harbors of Mendocino, Humboldt Bay, Trinidad, and Crescent City, in the State of California, with a view to establishing a breakwater and harbor of refuge, with estimate of probable cost, the Board of Engineers of the Pacific Coast was instructed to consider the general subject and report its views as to the necessity for a harbor of refuge on the Pacific coast between San Fran-

cisco and Puget's Sound, and in case such necessity should, in its opinion, exist, to designate the point which should, in its judgment, be selected, together with an estimate of cost of construction. For the report of the board see Appendix J J 5.

IMPROVEMENT AND CARE OF PUBLIC BUILDINGS AND GROUNDS IN THE DISTRICT OF COLUMBIA—WASHINGTON AQUEDUCT.

Officers in charge, Col. O. E. Babcock, Corps of Engineers, until March 3, 1877, since which time Lieut. Col. Thos. Lincoln Casey, Corps of Engineers.

1. *Improvement and care of Public Buildings and Grounds in the District of Columbia.*—The condition of the public reservations in the city of Washington, and the character of the improvements made on them during the fiscal year, will be found stated in the detailed reports of the officers in charge.

The estimates of the officer now in charge for the fiscal year ending June 30, 1879, are as follows:

For improvement and care of public buildings and grounds	$216,700
For compensation to persons employed on and around public buildings and grounds	59,524
For contingent and incidental expenses	1,900
	278,124

(See Appendixes K K 1 and K K 2.)

2. *Washington Aqueduct.*—During the year a wrought-iron truss-roof and galvanized-iron cornice have been erected upon the gate-house at Great Falls.

A number of the conduit-embankments have been strengthened by widening. The roadway over the conduit, the culverts and bridges, the reservoirs and gate-houses, and the pipe-lines have been kept in repair.

In Georgetown, a concrete floor has been laid in the high-service reservoir, and a brick story has been built under the aqueduct office.

The estimates of the officer in charge for the fiscal year ending June 30, 1879, are as follows:

For engineering, maintenance, repairs, and construction $116,000

(See Appendices K K 1 and K K 3.)

In January last, Brig. Gen. M. C. Meigs called the attention of this office to a communication made by him to the chairman of the Committee on the District of Columbia of the Senate of the United States relative to the construction of the iron bridge at Rock Creek by which the aqueduct mains enter the city of Washington. His communication was submitted to a board of engineer officers, whose report upon the same, together with the reports of the officers then and now in charge of the Washington Aqueduct, constitute Appendix K K 4 of this report.

The officer in charge of the aqueduct says:

> In view of the restrictions authorized by Congress to be placed upon the travel over this bridge, I am of opinion that, if they are continued in force, the interests of the United States do not at present demand any increase of the width of the roadway and of the footway of the bridge; but I am further of opinion that the present and prospective interests of the citizens of Washington and Georgetown do demand an increase in the width of the roadway and of the footway, the present width being, of the roadway, only 17 feet, and of the footways, 4½ feet each.

He estimates the cost of the widening at $75,000.

SURVEYS AND EXAMINATIONS WITH A VIEW TO THE IMPROVEMENT OF RIVERS AND HARBORS.

For examinations and surveys of rivers and harbors, for which there is no special appropriation, an appropriation of $150,000 should be made

SURVEY OF NORTHERN AND NORTHWESTERN LAKES AND THE MISSISSIPPI RIVER.

Officer in charge, Maj. C. B. Comstock, Corps of Engineers, who had under his immediate orders the following officers of the Corps of Engineers: Capt. H. M. Adams, First Lieuts. D. W. Lockwood, C. F. Powell, and P. M. Price, and Second Lieut. T. N. Bailey; and the following principal assistant engineers: L. L. Wheeler, F. W. Lehnartz, O. B. Wheeler, F. M. Towar, A. C. Lamson, Frederick Terry, George Y. Wisner, A. R. Flint, R. S. Woodward, J. H. Darling, E. S. Wheeler, and G. A. Marr.

Major Comstock was temporarily relieved on the 24th of May, 1877, and until the end of the fiscal year the work was in charge of Capt. H. M. Adams, Corps of Engineers.

Progress of the work during the year.—On Lake Erie, the triangulation has been carried from Westfield, N. Y., to near Painesville, Ohio. The topography and hydrography have been carried from Ashtabula, Ohio, to Vermillion, Ohio.

The latitudes and longitudes of Mount Forest and Cairo, Ill., of Saginaw and Saint Louis, Mich., have been determined, and in conjunction with Capt. W. S. Stanton, United States Engineers, and Lieut. W. Hoffman, Eleventh Infantry, the longitudes of Fort Fetterman, Wyo. Ter., and Forts Stockton, Concho, and McKavett, Tex., have been determined.

A line of precise levels has been run between Escanaba and Marquette, Mich., to determine the difference of levels of Lakes Michigan and Superior.

Coast Charts Nos. 1, 2, 3, and 5, of Lake Michigan; No. 6, of Saint Lawrence River, and a chart of Detroit River, have been completed and photolithographed.

The survey of the Mississippi River has been carried from five miles above Cairo, Ill., to a point eight miles above Columbus, Ky. The small amount of money available for this survey permitted but little to be done.

Amount available for fiscal year 1877–'78	$110,000
Amount required for survey of northern and northwestern lakes and Mississippi River for fiscal year ending June 30, 1879, namely, for continuing surveys of Lake Erie; for determination of points in aid of State surveys and construction of maps; for continuation of triangulation south from Chicago and east to Lake Erie; for survey of Mississippi River, and miscellaneous..	218,500

(See Appendix L L.)

MILITARY, GEOGRAPHICAL, AND LAKE-SURVEY MAPS.

Three sheets exhibiting the positions of the troops of the opposing armies on the 1st, 2d, and 3d of July, 1863, at Gettysburg, have been completed, and an edition has been printed.

In the office of the Chief of Engineers.

Of the Atlanta campaign maps, the drawing of sheet 2 has been completed, and sheet 5 is nearly ready for photolithographing.

The map of the siege of Atlanta, on a scale of two inches to the mile, has been photolithographed, and an edition has been printed.

The following maps, illustrating the operations of the late war, have been photolithographed and printed:

Map of the battle-field of Bull Run.
Map of the battle-field of Perryville, Ky.
Map of the battle-field of Logan's Cross-Roads.
Map of the battle-field of Williamsburg, Va.
Map showing the operations of General G. W. Morgan at Cumberland Gap, 1862.

The military map of the United States has been revised. An edition has been printed and is now being distributed to the various military posts.

Considerable progress has been made in the compilation and drawing of the map of the territory of the United States west of the Mississippi River. This map is on a scale of 1 : 500,000.

A map of the Yellowstone and Missouri Rivers and their tributaries, with corrections and additions made under the direction of Maj. G. L. Gillespie, at Headquarters Division of the Missouri, has been engraved, printed, and distributed to the troops in the field.

Sheet No. 2 of a map of the Western Territories, by Major Gillespie, has also been printed and distributed to the troops.

A general map of the seat of war in the East has been compiled, and an edition printed by means of photolithography, and distributed to the Army.

Seven sheets of a map of Turkey in Europe, published by the imperial department of war, Austria, have also been reproduced by photolithography, and a small edition printed.

Lake-survey chart No. 4 of the Saint Lawrence River has been engraved on copper, and charts 5 and 6 have been photolithographed, and an edition printed as a preliminary in advance of the engraved edition. These two charts are now in the hands of the engraver.

Lake-survey chart of harbor of refuge at Sand Beach, Lake Huron, has been engraved on copper and an edition printed.

Lake-survey chart of the south end of Lake Michigan has also been engraved on copper and an edition printed.

Lake Michigan coast-charts Nos. 1 and 2 have been photolithographed, and a preliminary edition printed in advance of the engraved edition. These charts are now in the hands of the engraver. Charts 3 and 5 have been photolithographed, and an advanced edition published. These two charts have also been engraved on copper.

Charts 6 and 7 have been photolithographed and an edition published. Chart 4 is now in the hands of the photolithographer.

Lake-survey chart of Detroit River has been photolithographed, and a preliminary edition published. The chart is now in the hands of the engraver.

Lake Ontario coast-chart No. 1 is now in the hands of the photolithographer, in order that a preliminary edition may be printed, after which the chart will be engraved.

Lake-survey chart of Lake Saint Clair has been engraved on copper and an edition printed.

GEOLOGICAL EXPLORATION OF THE FORTIETH PARALLEL.

Mr. Clarence King, United States Civil Engineer, in charge.

During the year the operations of this survey have been entirely confined to office-work, consisting of the superintendence of the publication of the atlas and text.

There have been completed during the year Vol. VI, *Microscopical Petrography;* Vol. IV, *Paleontology and Ornithology;* and Vol. II, *Descriptive Geology.* The *Geological and Topographical Atlas* has also been finished, consisting of the following sheets: Paper cover, title-page, legend-sheet, sketch map of the Western Cordilleras, five geological maps in two sheets each, five topographical maps in two sheets each, and four sheets of general geological sections.

To complete the report there will be produced Vol. I, *Systematic Geology*, and Vol. VII, *Vertebrate Paleontology.* The latter volume, together with its illustrations, is now in active preparation at the hands of Professor Marsh, of the Yale Museum. Vol. I, Mr. King's own contribution to the report, is completed, requiring only revision and printing. The illustrations to Vol. I are all done.

It is hoped that the publication of the series of reports will be completed early in the ensuing year.

(See Appendix M M.)

GEOGRAPHICAL SURVEYS OF THE TERRITORY WEST OF THE ONE HUNDREDTH MERIDIAN.

Officer in charge, First Lieut. George M. Wheeler, Corps of Engineers, having under his orders First Lieuts. Eric Bergland and Samuel E. Tillman and Second Lieut. Thomas W. Symons, Corps of Engineers; First Lieut Rogers Birnie, jr., Thirteenth Infantry; First Lieut. Charles C. Morrison, Sixth Cavalry; and Second Lieut. M. M. Macomb, Fourth Artillery.

The following gentlemen have been engaged in special scientific investigations during the year: Dr. F. Kampf, astronomical and triangulation observer and computer; A. R. Conkling, geologist; H. W. Henshaw, ornithologist; Dr. J. T. Rothrock, botanist; and Prof. F. W. Putnam, ethnologist.

Owing to the lateness of the appropriation act, the expedition of 1876 was only enabled to take the field in August, and was disbanded at Fort Lyon, Colo., and Carson City, Nev., during the latter part of November. The expedition of 1877, in three sections, took the field at Fort Lyon, Colo., Ogden, Utah, and Carson City, Nev., during the month of May. The number of small parties organized prosecuted their labors in parts of California, Oregon, Nevada, Utah, Idaho, Montana, Wyoming, Colorado, and New Mexico, and with the prospect of a long field-season only to be closed by the inclemency of the incoming winter at the high altitudes visited.

The areas surveyed by the expedition of 1876 lie in California, Nevada, Colorado, and New Mexico, and come within the limits of atlas sheets 47, 48, 56, 61, 62, 70, 77, and 78. (See progress map.)

The basins of drainage entered comprise portions of the "great interior basin," the Arkansas, Rio Grande, Gunnison, and several of the streams along the western slopes of the Sierra Nevada.

The astronomical stations at which latitude-determinations were made

were those necessary to the checking of the measured lines of survey through the mountain defiles.

Two bases were measured; 194 triangulation, 765 three-point, and 5,115 minor stations were occupied; 4,379 miles of survey were run; 168 monuments were built; 4,553 sets of altitude-observations were made; 15 mining camps were visited.

Of the quarto volumes authorized by Congress to be published, the one numbered IV has appeared during the year, and Vol. II is passing through the press.

The tables of declinations of 2,018 latitude-stars, prepared by Prof. T. H. Safford, are in the hands of the printer.

With slight exceptions the MSS. for Vols. I, VI, and VII of the series are ready to be placed in the hands of the printer; and the illustrations have all been prepared, and are now being engraved and printed.

Seven topographical sheets have been added to the atlas, and a number of others are being completed and in various stages of progress.

The edition of colored maps published with the extra copies of the report exhibit the natural resources of the country, and are of value in connection with the settlement of the western region. In the areas given, the land branch of the Government may be able to see at a glance the adaptability of the surface for agriculture or grazing, and the area of timber, position of mines, &c. The special surveys of the Lake Tahoe region, and about the Comstock mines, the maps from both of which are to be shown on scales larger than those usually employed, will illustrate some of the best topographical efforts of the survey, and prove useful to the mining and lumber interests of that section.

The topographical maps which are the main results of the labors of the officers and assistants, and regularly issued as material is collected, are at once available to the War Department for its purposes, and reach the public in the regular course of publication, and through map publishers at home and abroad.

The continuation of this useful work in its present satisfactory stage of organization will, it is hoped, commend itself to the favorable consideration of Congress.

The amounts estimated by Lieutenant Wheeler for the continuation of the survey are recommended, viz:

For continuing the geographical survey of the territory of the United States west of the one hundredth meridian, the supply branches of the War Department assisting as heretofore, being for field and office work, and for the preparation, engraving, and printing of the maps, charts, plates, cuts, photographic plate, and other illustrations for reports; for temporary office-room at points remote from Washington, D. C., and the purchase at nominal rates of sites for field observations, for the fiscal year ending June 30, 1877 .... $120,000 00

(His annual report, with appendixes and estimates, is appended.)

(See Appendix N N.)

RECONNAISSANCES AND EXPLORATIONS.

The engineer officers on the staffs of the generals commanding the military divisions and departments have been engaged during the year in surveys in the field and in collecting and plotting geographical and other information obtained from the note-books, sketches, and maps made by the officers and soldiers in the scouts and campaigns in the West. The estimate of $50,000 made by this department for the surveys

by these officers failed at the last session of Congress, and the only funds available for their use during the year was a part of a balance of $18,000 from a former appropriation for surveys for sea-coast defenses, which was also made applicable at the last session of Congress for reconnaissances and explorations by the engineer officers on the staffs of the western divisions and departments. The amount was quite inadequate for the work which was desired to be accomplished in the seven military departments embracing the country west of the Mississippi River, in each one of which there is an engineer or an acting engineer officer. This work includes surveys in the field by the department engineers, the purchase and repair of instruments, and the expenses attending the draughting and printing of maps required for distribution to the Army.

The maps of the country covered by the recent campaigns against hostile Indians have proved in the highest degree useful to the officers engaged, and it is especially desirable that the great unexplored areas in the hostile country and areas which in future campaigns are liable to be traversed by the troops or by the enemy should be surveyed and plotted and added to these campaign maps. The enlistment of topographical assistants to the engineer officers attached to the headquarters of each of the western military geographical divisions and departments which was authorized by the Secretary of War in July last will very much facilitate the surveys of those officers, and it is hoped, if the appropriation asked for for these surveys is granted by Congress, that much more can be accomplished than has been heretofore by the same amount of expenditure.

An estimate for the amount required to be appropriated for this purpose has been included in the estimates of this Department.

The officers who have been engaged on these surveys during the last fiscal year are as follows:

Maj. O. M. Poe, aid-de-camp (with the rank of colonel) to the General of the Army; Maj. G. L. Gillespie, at headquarters Division of the Missouri until May 5, 1877, and Capt. G. J. Lydecker since that date; Lieut. Edward Maguire, at headquarters Department of Dakota; Capt. W. S. Stanton, at headquarters Department of the Platte; Lieut. E. H. Ruffner, at headquarters Department of the Missouri; Capt. James F. Gregory, at headquarters Department of Texas; Lieut. J. C. Mallery, at headquarters Division of the Pacific and Department of California; and Lieut. E. D. Thomas, Fifth Cavalry, Department of Arizona.

Maj. George L. Gillespie, on duty with the Lieutenant-General commanding the Division of the Missouri, until May 5, 1877, when he was relieved by Capt. Garrett J. Lydecker.

Captain Lydecker reports that for want of funds operations have been limited to current office-work, such as could be done by enlisted men detailed for the purpose; duplicate tracings of maps, sketches, &c., passing through the office, have been made, and corrections have been applied to existing maps, as opportunity offered.

Work on the new maps of the western territories was necessarily suspended and cannot be resumed until a sufficient allotment of money is made applicable thereto. These maps are greatly needed and should be pushed to completion with the least possible delay. For this purpose and for conducting the work of this office in an efficient manner, the following amounts are required:

For the fiscal year ending June 30, 1878	$3,000 00
For the fiscal year ending June 30, 1879	6,000 00

(See Appendix O O.)

Lieut. Edward Maguire, serving on the staff of the general commanding the Department of Dakota, reports his topographical work in the field and office during the year. He also gives a detailed statement of his operations in the expedition against the hostile Sioux in the summer of 1876.

(See Appendix P P.)

Capt. W. S. Stanton, on duty with the general commanding the Department of the Platte, reports that during the year the field-work has comprised between 500 and 600 miles of reconnaissance, four small surveys, embracing 11⅜ square miles, and the determination of the geographical position of Fort Fetterman.

In the office the field-notes and astronomical observations taken on 900 miles of reconnaissance have been reduced and computed, and the map partially plotted; 60 plots and tracings of topographical drawings have been made, 1,660 maps and 191 printed reports have been distributed, and a considerable mass of information collected from various sources regarding the military reservations in the department.

(See Appendix Q Q.)

Lieut. E. H. Ruffner has been on duty as the engineer officer on the staff of the general commanding the Department of the Missouri. The work of recording, preparing and making use of the reports of the various journals of march made during the year on the department maps is continued. The notes thus recorded amount to 4,909 miles. The notes collected on a survey of the headwaters of the Red River of Texas have been worked upon and a partial report is furnished.

Military reservations at Fort Stanton, New Mexico; Fort Elliot, Texas, and Fort Reno, Ind. Ty., have been declared, surveyed, and recommended, respectively, and the plats form part of the records of the office.

Lieut. C. A. H. McCauley, Third Artilery, is engaged on a reconnaissance in the mining regions of Southern Colorado, to report on roads and number of settlers found. An allotment of $1,200 has been made for the service of the office for the year ending June 30, 1878, and an estimate of $5,000 made for the year ending June 30, 1879.

(See Appendix R R.)

Capt. James F. Gregory, on duty at the headquarters Department of Texas, reports that, in consequence of want of funds for the purpose, but little topographical work was done during the year. This work comprised a survey of the post of Ringgold Barracks, and determinations for latitude and longitude at Forts Richardson, Griffin, Stockton, Concho, and McKavett.

(See Appendix S S.)

Lieut. J. C. Mallery, at headquarters Military Division of the Pacific, reports that the discharge of the office employés at the close of the preceding fiscal year prevented the completion of four important maps which have been much needed.

Field-work.—The eastern boundary of the Presidio military reservation, as defined by the act of Congress of May 9, 1876, was surveyed and marked by stone monuments.

The boundaries of the Point San José military reservation were surveyed and marked.

A survey of the military reservation at Camp Thomas, Arizona Territory, was made by First Lieut. E. D. Thomas, Fifth Cavalry, A. D. C., and acting engineer officer, Department of Arizona.

A plan for preventing the drifting of sand upon the military reserva-

tion of Point San José was executed. The sand upon the reservation was fixed by producing a growth of barley and of lupine bushes. The sand blowing upon the reservation from the exterior was arrested at the boundary-lines by brush fences.

Office work.—Information has been collected for the publication of an outline description of the military posts in the military division of the Pacific. Work has been commenced in making reduced drawings of the plans of the military reservations and posts, to accompany this publication.

The following is an abstract of the office-work, viz: Drawings, 23; tracings, 58; maps mounted and backed, 45.

(See Appendix T T.)

Lieut. E. D. Thomas, Fifth Cavalry, acting engineer officer, Department of Arizona, reports that a survey of Camp Thomas military reservation was made in November, 1876. In his detailed report of his operations he has furnished this office with a full account of the military scouts in the department during the year, accompanied by a map on which the new geographical information has been plotted. His report also includes important information concerning the military roads of Arizona, and a detailed statement of what is required for their improvement and the estimated cost of the same.

(See Appendix U U.)

ESTIMATES FOR AMOUNTS REQUIRED FOR MILITARY AND GEOGRAPHICAL SURVEYS, EXPLORATIONS, AND RECONNAISSANCES.

For military surveys and reconnaissances by the engineer officers attached to the various headquarters of military divisions and departments, for extra-duty pay of enlisted topographical assistants, and for the construction and publication of maps for use of the War Department and the Army, $50,000 will be required.

For geographical surveys of the territory of the United States west of the one hundredth meridian, there will be required for field and office work, and for preparing, engraving, and printing of plates and atlas-sheets, $120,000.

OFFICE OF THE CHIEF OF ENGINEERS.

In the labors of the office I was assisted, on the 30th of June, by the following officers in charge of the several divisions:

FIRST AND SECOND DIVISIONS.—*Fortifications, battalion, and engineer depot, lands, armaments, personnel, &c.*, Lieut. Col. Thos. L. Casey, in addition to his other duties; and Capt. W. J. Twining.

THIRD DIVISION.—*River and harbor improvements, &c.*, Maj. John G. Parke.

FOURTH AND FIFTH DIVISIONS.—*Property accounts, estimates, funds, survey of the lakes, explorations, maps, instruments, &c.*, Maj. George H. Elliot.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brig. Gen., Chief of Engineers,
Commanding Corps of Engineers.

Hon. GEORGE W. MCCRARY,
Secretary of War.

STATEMENT SHOWING RANK AND DUTIES OF OFFICERS OF THE CORPS OF ENGINEERS DURING THE FISCAL YEAR ENDING JUNE 30, 1877.

Rank and Name.	Duties.
BRIGADIER GENERAL AND CHIEF OF ENGINEERS.	
Andrew A. Humphreys.. *Brt. Major General.*	Commanding Corps of Engineers. Member of Board for the survey of the harbor of Baltimore City and adjacent waters. Member of Joint Commission to supervise the construction of the Washington Monument. Member of Advisory Board to Harbor Commissioners, State of Massachusetts. Member of Board to determine pier and bulkhead lines of New York Harbor along Staten Island shore. Member of Commission to examine into the matter of contracts between the United States and the Moline Water-Power Company. To co-operate with authorities of the State of New York in examining and deciding upon exterior pier and bulkhead lines on Hudson River from State dam at Troy to the city of Hudson.
COLONELS.	
John G. Barnard........ *Brt. Major General.*	Member of Board of Engineers for Fortifications. Member of Lighthouse Board. Member of Commission to report an opinion upon certain subjects connected with improvement of South Pass of the Mississippi River. Member of Board of officers for examination of Lieutenant Taber for promotion.
Henry W. Benham...... *Brt. Major General.*	In charge of construction of Forts Winthrop, Independence, and Warren, and work on Long Island Head, Mass.
John N. Macomb........	In charge of improvement of the upper Mississippi and Illinois rivers, and Des Moines and Rock Island rapids of the Mississippi River, harbors of Fort Madison, Burlington, and Dubuque, Iowa. The survey for the improvement of that portion of the "Mississippi route" designated by the Senate Select Committee on Transportation-Routes to Seaboard, as improvements upon a system to be provided so as to give from 4½ to 6 feet depth of water at lowest stages from Falls of St. Anthony to Alton. Member of Board to inquire into the expediency of causing sheer-booms to be placed on upper end of all or any bridge-piers in Mississippi River.
James H. Simpson ...... *Brt. Brig. General.*	In charge of improvement of Osage River and Mississippi River between the mouths of the Illinois and Ohio rivers. Member of Board to inquire into the expediency of causing sheer-booms to be placed on upper end of all or any bridge-piers in Mississippi River.
Israel C. Woodruff...... *Brt. Brig. General.*	On detached service. Engineer 3d Lighthouse District. Member of Board to report upon improvement of harbor at Buffalo, N. Y.
Zealous B. Tower....... *Brt. Major General.*	Member of Board of Engineers for Fortifications. Member of Board to consider and report upon the necessity, &c., of certain projected modifications to the Rock Creek Bridge of the Washington Aqueduct. Member of Board of officers for examination of Lieutenant Taber for promotion. Member of Board of officers to consider questions relating to the improvement of the navigation of the Ohio River.
LIEUTENANT COLONELS.	
Horatio G. Wright...... *Brt. Major General.*	Member of Board of Engineers for Fortifications. Member of Commission on repavement of Pennsylvania Avenue, Washington, D. C. Member of Commission to report an

Statement showing rank and duties of officers of Corps of Engineers—Con'd.

RANK AND NAME.	DUTIES.
LIEUTENANT COLONELS. (continued.)	opinion upon certain subjects connected with improvement of South Pass of Mississippi River. Member of Board to consider and report upon the necessity, &c., of certain projected modifications to the Rock Creek Bridge of the Washington Aqueduct. Member of Board of officers for examination of Lieutenant Taber for promotion. Member of Board of officers to consider questions relating to the improvement of the navigation of the Ohio River. Member of Commission to examine into the matter of contracts between the United States and the Moline Water-Power Company.
John Newton............ *Brt. Major General.*	In charge of construction of Forts Montgomery, Columbus, Castle Williams, south battery Governor's Island, Wood, Hamilton, and additional batteries, mortar battery at Fort Hamilton, N. Y., and fort at Sandy Hook, N. J. Manufacture and supply of mastic; improvement of the Hudson River, East Chester Creek, and Harlem River, N. Y., Otter Creek, Vt., and Passaic River, N.J.; removal of obstructions in the East River, including Hell Gate, N. Y.; improvement of channel between Staten Island and New Jersey; harbor improvements at Burlington and Swanton, Vt., Rondout, Portchester, and Plattsburgh, N. Y. The survey of so much of the 3d subdivision of the "Northern route" designated by the Senate Select Committee on Transportation-Routes to Seaboard as extends from Troy, on the Hudson River, to New York City, until April 21, 1877. Examination and survey of Port Henry, Lake Champlain. To co-operate with authorities of the State of New York in examining and deciding upon exterior pier and bulkhead lines on Hudson River from State dam at Troy to the City of Hudson.
George Thom............ *Bvt. Brig. General.*	In charge of works for improvement of rivers St. Croix, Machias, Penobscot, Kennebec, Kennebunk, Me., Cocheco, N. H., and Merrimac, Mass.; of harbors of Camden, Portland, Richmond's Island, Belfast, Me., Gloucester, Salem, Boston, Plymouth, and Provincetown, Mass. Construction of sea-walls of Great Brewster, Deer, and Lovell's islands, Boston Harbor.
John D. Kurtz........... *Brt. Colonel.*	In charge of construction of Forts Delaware, Del., and Mifflin, Pa., battery at Finn's Point, N. J., and work opposite Fort Delaware, piers at Newcastle and Lewes, Del.; harbor improvements at Wilmington, Del., and on Delaware River and Bay; improvement of the Shrewsbury River and Cohansey Creek, N. J., Delaware and Broadkiln rivers, Del., and Schuylkill River, Pa. Member of Board to examine and report upon the foundation of the Washington Monument.
Barton S. Alexander .... *Brt. Brig. General.*	Senior Engineer charged with general supervision and inspection of all matters under the command of the Chief of Engineers within the Pacific territory. Member of Board of Engineers for Fortifications on the Pacific Coast. Member of Commission to report an opinion upon certain subjects connected with improvement of South Pass of Mississippi River.
William F. Raynolds.... *Brt. Brig. General.*	On detached service. Engineer 4th Lighthouse District.
Charles S. Stewart......	In charge of construction of fortifications at Fort Point, Point San José and Angel Island, San Francisco, and at San Diego, Cal., and improvement of San Diego Harbor and San Joaquin River, Cal. Member of Board of Engineers for Fortifications on the Pacific Coast.

Statement showing rank and duties of officers of Corps of Engineers—Con'd.

RANK AND NAME.	DUTIES.
LIEUTENANT COLONELS. (continued.)	
Charles E. Blunt........ *Bvt. Colonel.*	In charge of improvement of harbors of Port Clinton, Monroe, Toledo, Sandusky City, Huron, Vermillion, and Black River, on Lake Erie, until December 1, 1876. In charge of improvement of harbors of Rocky River, Cleveland, Grand River, Ashtabula, Conneaut, Erie, Dunkirk, and Buffalo, on Lake Erie, and construction of Fort Porter, N. Y., and of Fort Wayne, Mich., Engineer of 10th Lighthouse District until December, 30, 1876. Member of Board to report upon improvement of harbor at Buffalo, N. Y. Member of Commission to consider matter of occupancy of East Pier at Cleveland, Ohio, by the Pittsburgh and Cleveland Railroad Company.
James C. Duane .... *Bvt. Brig. General.*	In charge of construction of Forts Gorges, Preble, Scammel, Popham, Knox, and battery at Portland Head, Me., and Forts Constitution and McClary, and batteries on Jerry's Point and Gerrish's Island, Portsmouth Harbor, N. H. Engineer 1st and 2d Lighthouse districts. Member of Board to examine and report upon the foundation of the Washington Monument.
Robert S. Williamson ...	On detached service. Engineer 12th Lighthouse District. Member of Board of Engineers for Fortifications on the Pacific Coast.
Quincy A. Gillmore...... *Bvt. Major General.*	In charge of construction of Forts Wadsworth, Tompkins, and its batteries, N. Y., Macon and Caswell, N. C., Moultrie, Sumter, Johnson, and Castle Pinckney, S. C., Jackson and Pulaski, Ga., Clinch and Marion, Fla., and temporary charge of Forts Monroe and Wool, Va. Improvement of the bar at the mouth of St. John's River, and of the inside passage between St. John's River and Nassau Inlet, Fla., Charleston Harbor, S. C., Savannah River and Harbor. Member of Board to test the strength and value of all kinds of iron, steel, and other metals submitted to it. Member of Commission on repavement of Pennsylvania Avenue, Washington, D. C. Member of Board to examine and report upon the foundation of the Washington Monument. Member of Board of officers to take into consideration and report upon the necessity, &c., of certain projected modifications to the Rock Creek Bridge of the Washington Aqueduct.
Thos. Lincoln Casey .... *Bvt. Colonel.*	In charge of the 1st and 2d Divisions, Office of the Chief of Engineers; of Public Buildings and Grounds and certain public works in the District of Columbia, with the rank of Colonel; of work upon the building for the State, War, and Navy Departments, and of the Washington Aqueduct. Member of Board to advise upon the ventilation of the Hall of the House of Representatives.
MAJORS.	
Nathaniel Michler ...... *Bvt. Brig. General.*	In charge of improvement of harbors of Port Clinton, Monroe, Toledo, Sandusky City, Huron, Vermillion, and Black River, on Lake Erie.
John G. Parke.......... *Bvt. Major General.*	In charge of the 3d Division, Office of the Chief of Engineers.
Gouverneur K. Warren.. *Bvt. Major General.*	In charge of construction of defenses of New Bedford Harbor, Mass., Narragansett Bay, R. I.; improvement of harbors of Wareham, Hyannis, Fall River, and New Bedford, Mass., Wickford and Newport, R. I.; improvement of rivers Taunton, Mass., Pawtucket and Providence, R. I., Pawcatuck, R. I. and Conn., and Connecticut, Conn.. Construction of Breakwater at Block Island, R. I. Im-

Statement showing rank and duties of officers of Corps of Engineers—Con'd.

RANK AND NAME.	DUTIES.
MAJORS. (continued.)	provement of Little Narragansett Bay, R. I. and Conn. Member of Board to inquire into the expediency of causing sheer-booms to be placed on upper end of all or any bridge-piers in Mississippi River. Examining and reporting upon constructing railroad-bridges across the Mississippi River, between St. Paul and St. Louis, &c.
George H. Mendell...... *Brt. Colonel.*	In charge of construction of fort on Alcatraz Island, and of defenses at Lime Point, San Francisco Bay; Breakwater at Wilmington Harbor, Cal.; removal of Rincon Rock, in the harbor of San Francisco, Cal.; improvement of Oakland Harbor, and Sacramento and Feather rivers, Cal. Member of Board of Engineers for Fortifications on the Pacific Coast. Member of Advisory Board of Commissioners on the Harbor lines of San Francisco.
Henry L. Abbot.......... *Brt. Brig. General.*	Commanding Engineer Depot and Post of Willets Point, and Battalion of Engineers. In charge of construction of Fort Schuyler and fort at Willets Point, N. Y., and of experiments with torpedoes. Member of Commission to examine into the matter of contracts between the United States and the Moline Water-Power Company.
William P. Craighill .... *Brt. Lieut. Colonel.*	In charge of construction of defenses of Baltimore, Md., and Washington, D. C., improvement of Susquehanna, Patapsco, Chester, Wicomico, and Elk rivers, Md.; James and Appomattox rivers, Va., Great Kanawha and New rivers, W. Va., and Cape Fear River, N. C., and of the harbors of Baltimore and Crisfield, Md. The survey of that portion of the "Central route" designated by the Senate Select Committee on Transportation Routes to the Seaboard as a connection by canal or freight railway from the Ohio River or Kanawha River, near Charleston, by the shortest and most practicable route, through West Virginia to tidewater in Virginia; and the improvement of the Kanawha River from its mouth to Great Falls, so as to give 6 feet navigation at all seasons. Member of Board for survey of the harbor of Baltimore City and adjacent waters.
Cyrus B. Comstock..... *Brt. Brig. General.*	In charge of Survey of Northern and Northwestern Lakes and the survey of the Mississippi River until May 24, 1877. Detailed to report upon the depth and width of a channel secured and maintained by jetties constructed by James B. Eads at mouth of Mississippi River until May 28, 1877. Member of Board to report upon improvement of harbor at Buffalo, N. Y.
Godfrey Weitzel .... *Brt. Major General.*	In charge of improvement of the Falls of the Ohio River, and Louisville and Portland Canal, of St. Mary's Falls Canal; St. Mary's, St. Clair, and Sebawaing rivers, Mich.; of harbors of Au Sable River, Black River, and Thunder Bay; Harbor of Refuge on Lake Huron, and removal of obstructions from Detroit River. In charge of St. Clair Flats Canal, Saginaw River, Mich., and of Harbor of Cheboygan until March 19, 1877. Survey of the National Park on the Island of Mackinac. Engineer 11th Lighthouse District. Member of Board of officers to consider questions relating to the improvement of the navigation of the Ohio River. Member of Board of officers to examine and report upon certain changes proposed to be made in plan of harbor of Michigan City. Member of Board of officers to consider questions relating to the improvement of the navigation of the Wabash River.
Orlando M. Poe......... *Brt. Brig. General.*	On detached service. Aide-de-camp on the personal staff of the General of the Army with the rank of Colonel. Member of Lighthouse Board. Member of Board to retire disabled officers.

Statement showing rank and duties of officers of Corps of Engineers—Con'd.

RANK AND NAME.	DUTIES.
MAJORS. (continued.)	
David C. Houston....... *Bvt. Colonel.*	In charge of harbor improvements at Milwaukee, Racine, and Kenosha; improvement of the Fox and Wisconsin rivers. Member of Board of officers to examine and report upon certain changes proposed to be made in plan of harbor of Michigan City.
George H. Elliot........	In charge of the 4th and 5th Divisions, Office of the Chief of Engineers.
Henry M. Robert........	In charge of harbor improvements at Ontonagon, Eagle Harbor, and Marquette, Mich., Menomonee, Mich. and Wis., Green Bay, Ahnepee, Two Rivers, Manitowoc, Sheboygan, Port Washington, and Harbor of Refuge at entrance of Sturgeon Bay Canal, Wis.
William E. Merrill...... *Bvt. Colonel.*	In charge of improvement of the Ohio and Monongahela rivers, and the Little Kanawha River, W. Va. Engineer 14th Lighthouse District. In charge of the improvement of the Wabash River until January 22, 1877. Member of Board of officers to consider questions relating to the improvement of the navigation of the Ohio River. Member of Board of officers to consider questions relating to the improvement of the navigation of the Wabash River.
Walter McFarland......	In charge of construction of Forts Ontario and Niagara, N. Y.; of harbor improvements at Olcott, Oak Orchard, Charlotte, Pultneyville, Big Sodus, Little Sodus, Oswego, Black River, Ogdensburg, Wilson, and Waddington, N. Y. In charge of the survey designated by the Senate Select Committee on Transportation Routes to the Seaboard as the "Southern route," viz, 1st, for the improvement of the Tennessee River from its mouth to Knoxville, so as to give 3 feet depth at lowest stages of water; and 2d, a communication by canal or freight railway, from some convenient point on the Tennessee River in Alabama, or Tennessee, by the shortest and most practicable route to the Atlantic Ocean. Engineer 10th Lighthouse District.
Orville E. Babcock...... *Bvt. Brig. General.*	In charge of Public Buildings and Grounds, and certain public works in the District of Columbia with the rank of Colonel; of work on the east wing of the building for the State, War, and Navy Departments; of Washington Aqueduct until March 3, 1877. On detached service. Engineer 5th Lighthouse District.
John M. Wilson.......... *Bvt. Colonel.*	In charge of works for defense of the mouth of the Columbia River and improvement of the Willamette, Umpqua, Columbia, and Snake rivers. Construction of canal around the Cascades of the Columbia River. Demarkation and survey of Military Reservation on San Juan and adjacent islands in Puget Sound; examination and survey at mouth of Nehalem River and Alsea River and bar, Oreg. Engineer 13th Lighthouse District.
Franklin Harwood...... *Bvt. Lieut. Colonel.*	On detached service. Engineer 5th Lighthouse District until March 12, 1877. In charge of St. Clair Flats Canal, and improvement of Saginaw River and Cheboygan Harbor, Mich. Member of Board to report upon improvement of harbor at Buffalo, N. Y.
John W. Barlow .... *Bvt. Lieut. Colonel.*	In charge of Forts Griswold and Hale, and the construction of Fort Trumbull, Conn.; improvement of harbors of Stonington, New Haven, Bridgeport, Milford, Westport, Southport, and Norwalk, Conn., and Port Jefferson, N. Y.; improvement of Housatonic River, Conn., and Peconic River, N. Y.

Statement showing rank and duties of officers of Corps of Engineers—Con'd.

RANK AND NAME.	DUTIES.
MAJORS. (continued.)	
Peter C. Hains *Brt. Lieut. Colonel.*	On detached service. Engineer Secretary to Lighthouse Board.
Francis U. Farquhar *Brt. Lieut. Colonel.*	In charge of harbor improvements at Superior City, Superior Bay, and Duluth; improvement of Falls of St. Anthony, and of the Mississippi River above the Falls of St. Anthony; improvement of Chippewa and Minnesota rivers and the Red River of the North; construction of Meeker's Island lock and dam. In charge of the survey of that portion of the "Mississippi route" designated by the Senate Select Committee on Transportation Routes to the Seaboard as that for the construction of reservoirs at the sources of the river, and that for securing from 3 to 5 feet depth of water at lowest stage above the Falls of St. Anthony. Member of Board to inquire into the expediency of causing sheer-booms to be placed on upper end of all or any bridge-piers in Mississippi River.
George L. Gillespie *Brt. Lieut. Colonel.*	On detached service. Engineer Officer, Military Division of the Missouri. In charge of the construction of the harbors of Chicago, Calumet, Michigan City, and New Buffalo, under direction of the Chief of Engineers, until May 3, 1877. Member of Board of officers to examine and report upon certain changes proposed to be made in plan of harbor of Michigan City.
Charles R. Suter	In charge of improvement of the Mississippi, Missouri, Arkansas, White, and St. Francis rivers. The examination of that portion of the "Mississippi route" designated by Senate Select Committee on Transportation Routes to the Seaboard as that which relates to the plan and probable cost of securing a depth of from 8 to 10 feet at lowest stage of water between Cairo and New Orleans. Engineer 15th Lighthouse District. Member of Board to inquire into the expediency of causing sheer-booms to be placed on upper end of all or any bridge-piers in Mississippi River.
Jared A. Smith	In charge of construction of Forts Jefferson and Taylor, Fla., until Dec. 16, 1876. Engineer 7th Lighthouse District until Dec. 27, 1876. In charge of the improvement of the Wabash River. Member of Board of officers to consider and report upon certain questions in connection with improvement of the Wabash River.
Saml. M. Mansfield *Brt. Lieut. Colonel.*	In charge of harbor improvements at Charlevoix, Frankfort, Manistee, Ludington, Pentwater, White River, Muskegon, Grand Haven, Black Lake, Saugatuck, South Haven, and St. Joseph, on Lake Michigan.
CAPTAINS.	
William J. Twining *Brt. Major.*	On temporary duty in Office of the Chief of Engineers. In charge of survey of the Union Pacific and Central Pacific railways. On duty under Department of State, as chief astronomer and surveyor, upon Joint Commission for the survey of the boundary line along the 49th Parallel. On duty with Board of Arbitrators, Maryland and Virginia water-boundary.
William R. King *Brt. Major.*	In charge of improvement of the Tennessee River; Cumberland River above and below Nashville, Tenn., Tombigbee River, Miss., and Hiawassee River, Tenn., Oostenaula, Coosawattee, Etowah, and Ocmulgee rivers, Ga., and Coosa River, Ga. and Ala.
Wm. H. H. Benyaurd *Brt. Major.*	In charge of improvement of the Ouachita River in Louisiana and Arkansas, and of the Yazoo River in Mississippi, and Cypress Bayou, Texas; of water-gauges on the Mississippi River and its principal tributaries; removal of raft in Red River, La.; dredging at foot of Sodo Lake, Texas.

Statement showing rank and duties of officers of Corps of Engineers—Con'd.

RANK AND NAME.	DUTIES.
CAPTAINS. (continued.)	
Charles W. Howell...... *Brt. Major.*	In charge of construction of Forts Pike, Macomb, Tower Duprès, Battery Bienvenue, Tower at Proctorsville, Jackson, St. Philip, and Livingston. Improvement of the mouth of the Mississippi River at S.W. Pass, Galveston Harbor, Sabine Pass, and Red Fish Bar in Galveston Bay. Improvement and survey of ship-channel San Jacinto River to Bolivar Channel, Galveston Bay, Texas. Improvement of Pass Cavallo, Texas.
Garret J. Lydecker......	On duty under immediate orders of Major *Houston* until May 3, 1877. On detached service. Engineer Officer, Military Division of the Missouri. In charge of the construction of the harbors of Chicago, Calumet, Michigan City, and New Buffalo, under direction of the Chief of Engineers.
Arthur H. Burnham..... *Brt. Major.*	On duty under immediate orders of Colonel *Benham*.
Amos Stickney........... *Brt. Major.*	On duty under immediate orders of Colonel *Macomb*.
James W. Cuyler.........	On duty under immediate orders of Major *Craighill*.
Alexander Mackenzie ...	On duty under immediate orders of Major *Weitzel*.
Oswald H. Ernst.........	Commanding Company E, Battalion of Engineers. On duty at the U. S. Military Academy as instructor of Practical Military Engineering, Military Signaling, and Telegraphy.
David P. Heap...........	On duty under immediate orders of Major *Warren*. On temporary duty under Board of U. S. Executive Departments with International Exhibition of 1876.
William Ludlow......... *Bvt. Lieut. Col.*	On duty under immediate orders of Lieutenant Colonel *Kurtz*.
Charles B. Phillips......	On duty under immediate orders of Major *Craighill*. Member of Advisory Board to State Harbor Commission of Norfolk and Portsmouth.
William A. Jones.........	On detached service. Engineer 6th Lighthouse District.
Andrew N. Damrell ..... *Brt. Major.*	In charge of construction of defenses of Mobile and Pensacola, and fort on Ship Island, Miss.; improvement of harbor of Mobile; of Chattahoochie and Flint rivers, Ga., Apalachicola River, Fla., and Warrior and Tombigbee rivers, Ala.; removal of obstructions in the Choctawhatchie River, Ala., and Fla.; dredging the bar at mouth of harbor at Cedar Keys, Fla. Engineer 8th Lighthouse District.
Charles J. Allen .... *Brt. Major.*	On duty under immediate orders of Colonel *Simpson*. Member of Board to inquire into expediency of causing sheer-booms to be placed on the upper end of all or any bridge-piers in Mississippi River.
Charles W. Raymond....	On detached service. On duty at U. S. Military Academy.
Lewis C. Overman	On duty under immediate orders of Captain *King*.
Alexander M. Miller.....	On detached service. On duty at U. S. Military Academy until August 30, 1876. Commanding Company B, Battalion of Engineers. Member of general courts-martial to meet at Willets Point Nov. 28, 1876, and May 29, 1877.
Micah R. Brown	On duty under immediate orders of Major *Comstock* upon improvement of South Pass of the Mississippi River until May 28, 1877. Temporarily detailed to report upon the depth and width of a channel secured and maintained by jetties constructed by James B. Eads at the mouth of the Mississippi River.
Milton B. Adams.........	On duty under immediate orders of Lieutenant Colonel *Blunt*.

Statement showing rank and duties of officers of Corps of Engineers—Con'd.

RANK AND NAME.	DUTIES.
CAPTAINS. (continued.)	
Wm. R. Livermore	Commanding Company C, Battalion of Engineers. Member of general court-martial to meet at Willets Point, N. Y. Harbor, Nov. 28, 1876.
William H. Heuer.......	On duty under immediate orders of Lieutenant Colonel *Newton* until July 28, 1876. In temporary command of Company A, Battalion of Engineers. Additional member of general court-martial appointed to meet at Willets Point, N. Y. Harbor, July 18, 1876. Under Captain *Twining* on survey of the Union Pacific and Central Pacific railways. In charge of construction of Forts Jefferson and Taylor, Fla. Engineer 7th Lighthouse District.
William S. Stanton	On detached service. Engineer Officer, Department of the Platte.
A. Nisbet Lee...........	On duty under immediate orders of Major *Weitzel*.
Thomas H. Handbury ...	On detached service. On duty at U. S. Military Academy until Aug. 30, 1876. Commanding Company A, Battalion of Engineers. Member of general court-martial to meet at Willets Point, N. Y. Harbor, Nov. 28, 1876. Member of general court-martial to meet at Willets Point, May 29, 1877.
James C. Post	On duty under immediate orders of Lieutenant Colonel *Gillmore*. On temporary duty under Captain *Heap*, in connection with the International Exhibition of 1876.
James F. Gregory	On detached service. On duty under Department of State upon Joint Commission for survey of the boundary-line along the 49th Parallel. Under Captain *Twining* in survey of the Union and Central Pacific railways. Engineer Officer, Department of Texas. In charge of works for the protection of site of Fort Brown, Tex., under direction of the Chief of Engineers.
Henry M. Adams.	On duty under immediate orders of Major *Comstock* until May 24, 1877. In temporary charge of the Survey of Northern and Northwestern Lakes, and survey of the Mississippi River.
James Mercur..........	Commanding Company A, Battalion of Engineers until Aug. 5, 1876. Member of general court-martial to meet at Willets Point, N. Y. Harbor, July 18, 1876. On duty under immediate orders of Lieutenant Colonel *Newton* until April 21, 1877. In temporary charge of construction of Forts Montgomery, Columbus, Castle Williams, south battery Governor's Island, Wood, Hamilton and additional batteries, mortar battery at Fort Hamilton, and fort at Sandy Hook. Manufacture and supply of mastic. Improvement of the Hudson River, Harlem River, and East Chester Creek, N. Y., Otter Creek, Vt., and Passaic River, N. J.; removal of obstructions in the East River, including Hell Gate, N. Y.; improvement of channel between Staten Island and New Jersey; harbor improvements at Burlington, and Swanton, Vt., Rondout, Portchester, and Plattsburgh, N. Y. The survey of so much of the 3d subdivision of the "Northern route" designated by the Senate Select Committee on Transportation-Routes to Seaboard, as extends from Troy, on the Hudson River, to New York City.
FIRST LIEUTENANTS.	
Chas. E. L. B. Davis....	On duty under immediate orders of Captain *Howell*.
Benjamin D. Greene....	Quartermaster Battalion of Engineers. A. A. Q. M. & A. C. S., and recruiting officer Post of Willets Point. Member of general court-martial to meet at Willets Point, N. Y.

Statement showing rank and duties of officers of Corps of Engineers—Con'd.

Rank and Name.	Duties.
FIRST LIEUTENANTS. (continued.)	Harbor, July 18, 1876. Under Captain *Twining* in survey of the Union Pacific and Central Pacific railways. Adjutant Battalion of Engineers and Post of Willets Point. Post Treasurer and Signal Officer. Member of general court-martial to meet at Willets Point May 29, 1877.
John H. Weeden........	On duty under immediate orders of Lieutenant Colonel *Stewart*, and of the Board of Engineers for Fortifications on the Pacific Coast. Died January 29, 1877.
George M. Wheeler	In charge of Geographical Surveys of the territory west of the 100th meridian.
James B. Quinn..........	Commanding Company B, Battalion of Engineers. Under Captain *Twining* on survey of the Union Pacific and Central Pacific railways. Quartermaster Battalion of Engineers. A. A. Q. M. & A. C. S., and recruiting officer Post of Willets Point. Member of general court-martial to meet at Willets Point, N. Y. Harbor, May 29, 1877.
Daniel W. Lockwood....	On duty under immediate orders of Major *Comstock* until May 24, 1877. On duty under immediate orders of Captain *H. M. Adams*.
Ernest H. Ruffner	On detached service. Engineer Officer, Department of the Missouri. In charge of completion of military road from Santa Fé to Taos, N. M. On temporary duty under immediate orders of Captain *Heap* in connection with International Exhibition of 1876. Member of general court-martial to meet at Fort Leavenworth, Kas., Feb. 8, 1877.
John C. Mallery.........	On detached service. Engineer Officer, Military Division of the Pacific and Department of California. Member of general court-martial to meet at Alcatraz Island, Cal., May 23, 1877.
Clinton B. Sears	On duty under immediate orders of Colonel *Benham* until Aug. 28, 1876. On detached service. On duty at the U. S. Military Academy.
Thomas Turtle...........	On duty under immediate orders of Major *Craighill*.
Edward Maguire	On detached service. Engineer Officer, Department of Dakota. In charge of the improvement of the Missouri River above the mouth of the Yellowstone under the direction of the Chief of Engineers.
Frederick A. Mahan.....	On duty under immediate orders of Major *Merrill*. Recorder of Board of officers to consider questions relating to improvement of the navigation of the Ohio River.
Charles F. Powell.......	On duty under immediate orders of Major *Comstock* until May 24, 1877. On duty under immediate orders of Capt. *H. M. Adams*.
Frederick A. Hinman....	On duty under immediate orders of Major *Houston*.
Albert H. Payson	On duty at the U. S. Military Academy and with Company E, Battalion of Engineers, until March 8, 1877. On duty under immediate orders of Lieutenant Colonel *Stewart*, and of the Board of Engineers for Fortifications on the Pacific Coast.
John G. D. Knight	On detached service. On duty at the U. S. Military Academy.
Richard L. Hoxie	On detached service. Chief Engineer of the District of Columbia under the direction of the Board of Commissioners.
Edgar W. Bass..........	Adjutant Battalion of Engineers and Post of Willets Point; Post Treasurer and Signal Officer until Sept. 14, 1876. Member of general court-martial to meet at Willets Point, N. Y. Harbor, July 18, 1876. On detached service. On duty at the U. S. Military Academy.

Statement showing rank and duties of officers of Corps of Engineers—Con'd.

RANK AND NAME.	DUTIES.
FIRST LIEUTENANTS. (continued.)	
William L. Marshall	On duty under immediate orders of Lieutenant *Wheeler* on explorations west of 100th meridian until Aug. 8, 1876. On duty under immediate orders of Captain *King*.
Joseph H. Willard	On duty under immediate orders of Lieutenant Colonel *Newton* until April 21, 1877. On duty under immediate orders of Captain *Mercur*. Recorder of Board to examine and decide upon pier and bulkhead lines upon Hudson River, from the State dam at Troy to the city of Hudson.
Eric Bergland	On duty under immediate orders of Lieutenant *Wheeler*.
Samuel E. Tillman......	On duty at the U. S. Military Academy until Aug. 9, 1876. On duty under immediate orders of Lieutenant *Wheeler*.
Philip M. Price	On duty under immediate orders of Major *Comstock* until May 24, 1877. On duty under immediate orders of Capt. *H. M. Adams*.
Francis V. Greene.......	On detached service. On duty in the office of the Secretary of War until June 23, 1877. On duty under the Department of State as Military Attaché of the U. S. Legation at St. Petersburg.
Carl F. Palfrey	On detached service. On duty at the U. S. Military Academy. Member of general court-martial to meet at West Point, N. Y., Jan. 12, 1877.
William H. Bixby.......	On detached service. On duty at the U. S. Military Academy. On duty with Company B, Battalion of Engineers.
Henry S. Taber	On duty with Company B, Battalion of Engineers. Additional member of general court-martial appointed to meet at Willets Point, N. Y. Harbor, July 18, 1876. Battalion Quartermaster, A. A. Q. M., A. C. S., and R. O. Post of Willets Point until Dec. 22, 1876. On duty at the U. S. Military Academy, and with Company E, Battalion of Engineers.
SECOND LIEUTENANTS.	
William T. Rossell......	On duty with Company A, Battalion of Engineers, until Aug. 28, 1876. Member of general court-martial to meet at Willets Point, N. Y. Harbor, July 18, 1876. On detached service. On duty at the U. S. Military Academy.
Thomas N. Bailey.......	On duty under immediate orders of Major *Comstock*, until Aug. 23, 1876. On detached service. On duty at the U. S. Military Academy.
Thos. W. Symons	On duty with Company C, Battalion of Engineers, until Aug. 8, 1876. Judge-advocate of general court-martial to meet at Willets Point, N. Y. Harbor, July 18, 1876. On duty under immediate orders of Lieutenant *Wheeler*.
Smith S. Leach	On temporary duty under immediate orders of Captain *Heap* in connection with International Exhibition, 1876, until Sept. 14, 1876. Adjutant Battalion of Engineers and Post of Willets Point; Post Treasurer and Signal-officer, until Dec. 11, 1876. Member of general court-martial to meet at Willets Point, N. Y. Harbor, Nov. 28, 1876. On duty with Company C, Battalion of Engineers. Member of general court-martial to meet at Willets Point, N. Y. Harbor, May 29, 1877.
Dan C. Kingman	On duty with Company C, Battalion of Engineers. Member of general court-martial to meet at Willets Point, N. Y. Harbor, July 18, 1876. Judge-advocate of general court-martial to meet at Willets Point, N. Y. Harbor, May 29, 1877.

Statement showing rank and duties of officers of Corps of Engineers—Con'd.

Rank and Name.	Duties.
SECOND LIEUTENANTS. (continued.)	
Eugene Griffin	On duty with Company B, Battalion of Engineers. Judge-advocate of general court-martial to meet at Willets Point, N. Y. Harbor, July 18, 1876. Member of general courts-martial to meet at Willets Point, N. Y. Harbor, Nov. 28, 1876, and May 29, 1877.
Willard Young	On duty with Company A, Battalion of Engineers. Member of general court-martial to meet at Willets Point, N. Y. Harbor, July 18, 1876. Judge-advocate of general court-martial to meet at Willets Point, N. Y. Harbor, Nov. 28, 1876. Member of general court-martial to meet at Willets Point, N. Y. Harbor, May 29, 1877.
William M. Black	On graduating leave. } Appointed in the Corps of Engineers. June 15, 1877.
Walter L. Fisk	On graduating leave.
Solomon W. Roessler	On graduating leave.
U. S. CIVIL ENGINEERS.	
Clarence King	In charge of Geological Exploration of 40th Parallel.
S. T. Abert	In charge of improvement of Occoquan, Rappahannock, Elizabeth, and Nansemond rivers, Va., Roanoke, Pamplico, Perquimans, and French Broad rivers, N. C.; of Aquia, Accotink, and Nomini creeks, Va.; of the harbors of Washington and Georgetown, D. C., and Norfolk, Va.
M. Meigs	On duty under immediate orders of Colonel *Macomb*.

LAWS

AFFECTING

THE CORPS OF ENGINEERS.

FORTY-FOURTH CONGRESS, SECOND SESSION, 1876–'77.

CHAP. 25.—An act to amend an act entitled "An act authorizing the repavement of Pennsylvania avenue," and the act amendatory thereof. Jan. 16, 1877.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That so much of said act, and the act amendatory thereof, approved August fifteenth, eighteen hundred and seventy-six, as provides that the said pavement shall be fully completed and ready for use January fifteenth, eighteen hundred and seventy-seven, is hereby amended so as to extend the time for the completion of said work to the first day of June, eighteen hundred and seventy-seven: *Provided*, That the sureties in the contract for doing said work shall file with the said paving commissioners their consent in writing to the extension of time provided for in this act, and in default thereof that the contractors shall file a new bond to the satisfaction of the said paving commissioners, before said contractors shall be entitled to any benefits under the provisions of this act.

Act July 19, 1876, ch. 213, and act August 15, 1876, ch. 306, amended.

Time for paving Pennsylvania avenue extended.

Proviso.

Approved, January 16, 1877.

CHAP. 31.—An act authorizing the Commissioners of the District of Columbia to remove the jail on Judiciary Square to grounds near to the Washington Asylum for the use of the District. Jan. 20, 1877.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Commissioners of the District of Columbia are hereby authorized and empowered to tear down and remove the jail situate on Judiciary Square, in the city of Washington, and with the material thereof, and such other as may be necessary, to locate and construct, within the present year, a suitable building or buildings for the work-house of the Washington Asylum, for the use of said District, upon the following grounds, namely: Upon the public reservation in said city of Washington now occupied in part by the buildings of the Washington Asylum, beginning on the east side of Nineteenth street east, at the southwestern angle of the ground occupied by said Washington Asylum; running thence south along the east line of said street to the point at which the north line of E street, if prolonged, would intersect the east line of said Nineteenth street east; running thence east three hundred feet, thence north to the south boundary of the asylum grounds; thence west three hundred feet to the point of beginning; and that it shall be lawful to use said building or buildings and grounds for the imprisonment, under the laws, of persons sentenced to imprisonment by the police court of said District, or by the supreme court of said District, in cases appealed from said police court, for violation of the municipal laws or ordinances in force in said District.

Jail on Judiciary Square may be removed.

Use of material.

Location of new buildings.

Use of new buildings.

SEC. 2. That said Commissioners shall not expend more than fourteen thousand dollars in and about the aforesaid work of tearing down, removal, and construction; which sum is hereby appropriated for that purpose out of any money in the Treasury not otherwise appropriated.

Limit of cost.

Appropriation.

Grading, &c., square. Appropriation. 1874, c. 455, 18 Stat., 225.

SEC. 3. That, for the removal of earth and rubbish, grading, sewerage and other improvements of Judiciary Square, the sum of two thousand dollars is hereby appropriated out of any money in the Treasury not otherwise appropriated, in lieu of the money to have been derived from the sale of the jail in said square and appropriated June three, eighteen hundred and seventy-four.

Approved, January 20, 1877.

Feb. 28, 1877.

CHAP. 76.—An act to authorize the Ocean City Bridge Company to maintain and operate a bridge heretofore erected over and across Synepuxent Bay in Worcester County, Maryland.

Ocean City Bridge Company may maintain bridge.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Ocean City Bridge Company, a corporation created by an act of the general assembly of the State of Maryland, passed at the January session thereof, in the year eighteen hundred and seventy-six, be, and it is hereby, authorized to maintain and operate a bridge heretofore built across Synepuxent Bay, from Hommock Point to Ocean City in Worcester County in said State, with all the powers, rights, and franchises, and subject to all the conditions, duties, and obligations, which are conferred and imposed upon said corporation in and by the several provisions of the said act of incorporation.

Changes or removal of bridge.

SEC. 2. If the bridge authorized by the preceding section, shall at any time, in the opinion of the Secretary of War, substantially or materially obstruct the free navigation of the Synepuxent Bay, the same shall under the direction of the Secretary and at the expense of the owner or owners, be so altered or changed as to obviate the obstruction, and if in the opinion of the Secretary, the removal of the bridge shall be necessary to secure the navigation of said bay, such bridge shall within sixty days after notice to that effect, be removed by the owner or owners at his or their expense.

Approved, February 28, 1877.

March 3, 1877

CHAP. 102.—An act making appropriations for the legislative, executive, and judicial expenses of the Government for the year ending June thirtieth eighteen hundred and seventy-eight and for other purposes.

Appropriations. Legislative, executive, and judicial expenses.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated out of any money in the Treasury not otherwise appropriated, in full compensation for the service of the fiscal year ending June thirtieth eighteen hundred and seventy eight, for the objects hereinafter expressed, namely:

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PUBLIC BUILDINGS AND GROUNDS.

Salaries.

For clerk in the Office of Public Buildings and Grounds, one thousand four hundred dollars.

For messenger in the same office, eight hundred and forty dollars.

For public-gardener, one thousand six hundred dollars.

For the laborer in charge of the water-closets in the Capitol, seven hundred and twenty dollars.

For a foreman and laborers employed in the public grounds, fourteen thousand dollars.

For two laborers in the Capitol, one thousand four hundred and forty dollars.

Architect of Capitol to have charge of Capitol buildings.

For the person in charge of the heating-apparatus of the Library of Congress, and other steam-heating apparatus in the central building, eight hundred and sixty-four dollars; and the Architect of the Capitol shall hereafter have the care and superintendence of the Capitol, including lighting, and shall submit through the Secretary of the Interior annually estimates thereof.

Executive Mansion employés.

For the following employees at the Executive Mansion, namely: For furnace-keeper, eight hundred and sixty-four dollars; one night-watchman, at nine hundred dollars; one night-usher, at one thousand two hundred dollars; two day-ushers, one at the President's door and one

at the door of the secretary, at one thousand two hundred dollars each; and two doorkeepers, at one thousand two hundred dollars each; in all, seven thousand seven hundred and sixty-four dollars.

For two draw-keepers for Navy-Yard and Upper bridges, and for fuel, oil, and lamps, one thousand six hundred dollars. Draw-keepers.

For watchman in Franklin Square, seven hundred and twenty dollars. Watchmen in grounds.

For watchman at Lafayette Square seven hundred and twenty dollars.

For two watchmen in Smithsonian grounds, at seven hundred and twenty dollars each, one thousand four hundred and forty dollars.

For one bridge-keeper at Chain Bridge, seven hundred and twenty dollars.

For contingent and incidental expenses, five hundred dollars. Contingencies.

That there be allowed and paid to the two watchmen in the Smithsonian grounds, the two laborers in the Capitol building, one public gardener, and one watchman in Lincoln Square, discharged by reason of the second section of the act making appropriations for the legislative, executive, and judicial expenses of the Government for the fiscal year ending June thirtieth, eighteen hundred and seventy-seven, and for other purposes, approved August fifteenth, eighteen hundred and seventy-six, a sum equal to the amount of their respective pay from August sixteenth, eighteen hundred and seventy-six September fifteenth, eighteen hundred and seventy-six, four hundred and twenty dollars. Watchmen, &c., discharged. 1876, ch. 287, *Ante*, 163.

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WAR DEPARTMENT.

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In the Office of the Chief of Engineers.—One chief clerk at two thousand dollars; four clerks of class four; three clerks of class three; three clerks of class two; three clerks of class one; one messenger; two laborers; in all, twenty-four thousand and eighty dollars. Engineer Bureau.

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For contingent expenses, namely for stationery, office-furniture miscellaneous and incidental expenses, including purchase of professional books and maps, two thousand five hundred dollars.

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Approved, March 3, 1877.

CHAP. 105.—An act making appropriations for sundry civil expenses of the Government for the fiscal year ending June thirtieth, eighteen hundred and seventy-eight, and for other purposes. Appropriations.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and the same are hereby, appropriated, for the objects hereinafter expressed, for the fiscal year ending June thirtieth, eighteen hundred and seventy-eight, namely: Sundry civil expenses.

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UNDER THE TREASURY DEPARTMENT.

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MISCELLANEOUS OBJECTS.

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To protect the piers at the draw of the bridge across the Mississippi River at Rock Island Illinois owned by the United States, by the erection of booms, to be expended under the direction of the Secretary of War, fifteen thousand dollars, and the Chicago Rock Island and Pacific Railway Company is required to refund to the Treasury of the United States, one-half of the said sum, and the Secretary of the Treasury is hereby directed to enforce this condition. To protect piers of Rock Island bridge.

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UNDER THE WAR DEPARTMENT.

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Surveys of northern and northwestern lakes, &c.

SURVEYS OF NORTHERN AND NORTHWESTERN LAKES AND MISSISSIPPI RIVER: For continuing surveys of Lakes Erie and Ontario; determination of points in aid of State surveys and construction of maps; continuation of triangulation south from Chicago and east to Lake Erie; survey of the Mississippi River; and miscellaneous one hundred and ten thousand dollars. *Provided*, That the proceeds of the sale of the steamers belonging to the survey of the northern and northwestern lakes shall be placed in the Treasury to the credit of the appropriation of said survey and the whole amount shall be immediately available *Provided further* That twenty five thousand dollars of the foregoing sum shall be expended under the direction of the Chief of Engineers in continuing the survey of the Mississippi River and its tributaries with a view of determining the proper method of reclaiming from overflow the alluvial lands of the Mississippi delta.

Proceeds of sale of survey-steamers.

Proviso.

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Surveys and reconnaissances, maps.
1875, ch. 39, 18 Stat., 314.

The balance not to exceed eighteen thousand dollars of the appropriation of February tenth, eighteen hundred and seventy-five, for surveys for seacoast defences now standing on the books of the Treasury Department is hereby also made available for the surveys and reconnoisences by the engineer officers attached to the headquarters of the various military divisions and departments and for the publication of maps for the use of the War Department and the Army.

BUILDINGS AND GROUNDS IN AND AROUND WASHINGTON.

Public grounds in Washington, D. C.

Improvement and care of public grounds: For filling in and improving grounds south of Executive Mansion four thousand dollars.

For ordinary care and extension of greenhouses at the nursery, one thousand five hundred dollars.

For ordinary care of Lafayette Square one thousand dollars.

For care of and improvement of reservation No 3 Monumental Grounds one thousand dollars.

For annual repair of fences one thousand dollars.

For manure and hauling of the same, one thousand five hundred dollars.

For painting iron fences two thousand dollars.

For repair of seats five hundred dollars.

For purchase and repair of tools five hundred dollars.

For trees, tree stakes, lime and whitewashing two thousand dollars.

For removing snow and ice one thousand dollars.

For flowers, pots, twine and Italian lycopodium five hundred dollars.

For abating nuisances five hundred dollars.

For care of and repairs to fountains in the public grounds five hundred dollars.

For improving various reservations four thousand dollars.

No expenditure for removing iron fences.

Provided, That no sum of money herein appropriated shall be expended by the Commissioner of Public Buildings and Grounds to take down or remove any iron fence around any square or reservation in the city of Washington.

Bennings, Anacostia, and Chain bridges.

For ordinary repairs to Bennings and the Anacostia and Chain bridges one thousand dollars.

Pedestal for statute of General G. H. Thomas.
1876, ch. 246.

For pedestal for the statue of General George H. Thomas, the unexpended balance of the sum appropriated for this purpose in the act of July thirty first eighteen hundred and seventy six is hereby reappropriated and rendered available.

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Executive Mansion.

For repairs of the Executive Mansion, refurnishing the same, and fuel for the same and for care and necessary repairs of the greenhouses, twenty thousand dollars.

Lighting Executive Mansion, &c.

For lighting the Executive Mansion and public grounds, namely, for gas, pay of lamp lighters, gas fitters, plumbers and plumbing, lamps, lamp-posts, matches and repairs of all kinds, fuel for watchmen's lodges and for greenhouses at the nursery, fifteen thousand dollars: *Provided*, That the superintendent of meters at the Capitol shall hereafter take the statement of the meters of the several Department buildings in the

State of meters in Department

city of Washington and render to the proper accounting officers of the Treasury Department the consumption of gas each month in said buildings respectively. buildings to be taken. &c.

For repairing and extending water pipes, purchase of apparatus to clean them and for cleaning the springs that supply the Capitol, Executive Mansion and War and Navy Departments, four thousand dollars. Water pipes, &c.

Washington aqueduct: For engineering, maintenance and general repairs, fifteen thousand dollars. Washington Aqueduct.

For repairs and care of the telegraph to connect the Capitol with the Departments and the Public Printing Office, five hundred dollars. Department telegraph.

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For geographical surveys of the territory west of the one hundredth meridian, and for preparing, engraving and printing the cuts, charts, plates and atlas sheets for geographical surveys west of the one hundredth meridian, fifty thousand dollars, which shall be immediately available. Geographical surveys; charts, plates, &c.

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State, War, and Navy Department building: For continuation of the east wing of the building, two hundred and fifty thousand dollars, and for preparing granite for the construction of the north wing, one hundred and fifty thousand dollars; which shall be immediately available, and expended under the direction of the Secretary of War. State, War, and Navy Department building.

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Approved, March 3, 1877.

CHAP. 106.—An act making appropriations to supply deficiencies in the appropriations for the fiscal year ending June thirtieth, eighteen hundred and seventy-seven, and prior years, and for other purposes. March 3, 1877.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the following sums be, and they are hereby, appropriated, to supply deficiencies in the appropriations for the service of the Government for the fiscal year ending June thirtieth, eighteen hundred and seventy-seven, and for former years, and for other purposes, namely: Deficiency appropriations.

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WAR DEPARTMENT.

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OFFICE OF THE QUARTERMASTER-GENERAL.

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For payment of amounts certified to be due by the accounting-officers of the Treasury Department for bridge trains and equipage, being a deficiency for the fiscal year eighteen hundred and seventy-one, and prior years, two hundred dollars. Bridge-trains, &c.

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MISCELLANEOUS

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For payment of amounts certified to be due by the accounting-officers of the Treasury Department for expense of military and geographical surveys west of the Mississippi River, being a deficiency for the fiscal year eighteen hundred and seventy-three, twenty-two dollars and thirty cents. Geographical surveys.

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MISCELLANEOUS.

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And hereafter no contract shall be made for the rent of any building, or part of any building, to be used for the purposes of the Government in the District of Columbia, until an appropriation therefor shall have been made in terms by Congress, and that this clause be regarded as notice to all contractors or lessors of any such building or any part of building. Future leases in District of Columbia.

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Certain balances carried to surplus fund made available.
1874, ch. 328, § 5, 18 Stat., 110.

SEC. 2. That the following balances of appropriations, carried to the surplus fund under the provisions of the fifth section of the act approved June twentieth, eighteen hundred and seventy-four, being required to complete the service of the fiscal year eighteen hundred and seventy-four and prior years, are hereby continued and rendered available for such purpose, namely:

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WAR DEPARTMENT.

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MILITARY AND GEOGRAPHICAL SURVEYS WEST OF THE MISSISSIPPI RIVER.

Geographical surveys.

For payment of amounts certified to be due by the accounting-officers of the Treasury Department for expenses of military and geographical surveys west of the Mississippi River, being for the service of the fiscal year eighteen hundred and seventy-three, ten dollars and fifty-six cents.

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Approved, March 3, 1877.

March 3, 1877.

CHAP. 112.—An act making appropriations for fortifications and for other works of defense, and for the armament thereof, for the fiscal year ending June 30, 1878, and for other purposes.

Appropriations.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the sum of one hundred thousand dollars be, and the same is hereby appropriated out of any money in the Treasury not otherwise appropriated, for the protection preservation and repair of fortifications and other works of defense, for the fiscal year ending June thirtieth eighteen hundred and seventy-eight; the same to be expended under the direction of the Secretary of War; also, the following for armament of fortifications, namely:

Fortifications and other works of defense.

Armament of sea-coast fortifications.

Machine guns.

For the armament of sea-coast fortifications, including heavy guns, and howitzers for flank defense, carriages, projectiles, fuses, powder, and implements, their trial and proof, and all necessary expenses incident thereto, one hundred thousand dollars; and for Gatling or other machine guns, twenty-five thousand dollars.

Torpedoes for harbor defenses.

Proviso.

For torpedoes for harbor defenses, and preservation of the same, and for torpedo experiments in their application to harbor and land defense, and for instruction of engineer battalion in their preparation and application, fifty thousand dollars: *Provided*, That the money herein appropriated for torpedoes shall only be used in the establishment and maintenance of torpedoes to be operated from shore-stations for the destruction of an enemy's vessel approaching the shore or entering the channel and fairways of harbors.

Approved, March 3, 1877.

March 3, 1877.

[No. 6.] Joint resolution authorizing the President to designate and set apart a site for the colossal statue of "Liberty enlightening the world," and to provide for the permanent maintenance and preservation thereof.

Preamble.

Whereas, the President has communicated to Congress the information that citizens of the French Republic propose to commemorate the one hundredth anniversary of our independence by erecting at their own cost a colossal bronze statue of "Liberty enlightening the world" upon a pedestal of suitable proportions to be built by private subscription upon one of the islands belonging to the United States in the harbor of New York, and

Preamble.

Whereas it is proper to provide for the care and preservation of this grand monument of art and of the abiding friendship of our ancient ally: Therefore,

Statue of "Liberty enlightening the world" accepted.

Site for.

Be it resolved by the Senante and House of Representatives of the United States of America in Congress assembled, That the President of the United States be and he is hereby authorized and directed to accept the colossal statue of "Liberty enlightening the world" when presented by citizens of the French Republic, and to designate and set apart for the erection thereof, a suitable site upon either Governors or Bedloes

Island, in the harbor of New York; and upon the completion thereof shall cause the same to be inaugurated with such ceremonies as will serve to testify the gratitude of our people for this expressive and felicitous memorial of the sympathy of the citizens of our sister Republic; and he is hereby authorized to cause suitable regulations to be made for its future maintenance as a beacon, and for the permanent care and preservation thereof as a monument of art, and the continued good will of the great nation, which aided us in our struggle for freedom.

Inauguration of.

Approved, March 3, 1877.

[No. 8.] Joint resolution to appoint a commission to examine into the matter of contracts made by and between the United States and the Moline Water Power Company as to the water power at Moline, Illinois, and to report to Congress as to same.

March 3, 1877.

Preamble.

Whereas, the Moline Water Power Company, of Moline in the State of Illinois, complains that certain contracts made with said Company by the United States, through the Secretary of War, acting under the authority of Congress have not been carried out in good faith in developing and maintaining the water power at said town of Moline as required by said contracts, and that by reason of such failure said Company has sustained and is sustaining large damages, therefore,

Commission to examine Moline Water Power Company contracts.

Resolved, by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War be, and he is hereby, authorized and required to appoint a commission to consist of three competent Civil Engineers, one of whom shall be the Chief of Engineers of the United States Army, whose duty it shall be to examine into the subject matter of said contracts, made by and between the United States, as aforesaid, and the said Water Power Company, as to said water power, and the development and maintenance of the same, and to report to the Congress of the Congress of the United States at its next session, what if anything is necessary to be done by the United States to carry out in good faith said contracts, and to relieve said Water Power Company from its alleged grievances. Said report to be submitted through the Secretary of War, to the Congress of the United States at the commencement of its next session; and to be directed to the Speaker of the House of Representatives.

Report.

Approved, March 3, 1877.

APPENDIXES

TO THE

REPORT OF THE CHIEF OF ENGINEERS.

APPENDIXES

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REPORT OF THE CHIEF OF ENGINEERS.

APPENDIX A.

ANNUAL REPORT OF LIEUTENANT-COLONEL GEORGE THOM, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1877.

UNITED STATES ENGINEER OFFICE,
Portland, Me., July 7, 1877.

GENERAL: I have the honor to transmit herewith my annual reports of operations for the fiscal year ending June 30, 1877, on the several river and harbor improvements under my charge in the States of Maine, New Hampshire, and Massachusetts.

Very respectfully, your obedient servant,

GEO. THOM,
Lieut. Col. of Engineers, Bvt. Brig. Gen., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

A 1.

IMPROVEMENT OF SAINT CROIX RIVER, ABOVE THE "LEDGE," MAINE.

The following appropriations have been made by Congress for the improvement of this river, viz:

By act approved March 2, 1867	$15,000 00
By act approved March 3, 1873	10,000 00
By act approved June 23, 1874	10,000 00
Total	35,000 00

The act of March 2, 1867, contains the proviso that—

The province of New Brunswick contribute and pay to the proper disbursing officer a like sum for said purpose, said payment being made on condition that in no event shall the province of New Brunswick be called upon for more than half the sum actually expended for said purpose.

In July, 1873, information was received by the Department from the minister of public works of the Dominion of Canada that $25,000 had been appropriated by Parliament—

For the removal of slabs, sawdust, and other obstructions in the Saint Croix River, which runs between the province of New Brunswick and the State of Maine.

An accurate survey was made in 1873, under my direction, of this river from the "Ledge" up to the toll-bridge between Calais and Saint Stephen's, the head of navigation, and a project for the improvement

of this river, with an estimate of its cost, was submitted to both governments.

On referring to my estimate, submitted to the Department in a special report dated March 25, 1874, it is seen that about 235,000 cubic yards of slabs, edgings, &c., would have to be excavated in order to obtain a channel 200 feet wide and 9 feet deep at mean low-water (giving 29 feet at mean high-water) up to Todd's Ledge, and 100 feet wide, with same depth, thence up to the toll-bridge; the estimated cost of which now is $150,000.

Now, as these deposits in the channel have been caused solely by the saw-mills at Calais, Saint Stephen's, and above, and as there does not appear to be any law or authority strong enough to prevent the continuance of this evil, it has been decided by the two governments (see correspondence accompanying my annual report for the fiscal year ending June 30, 1874) to suspend this improvement until they shall become satisfied that there will be no further deposition of the "waste" from the saw-mills above, as otherwise there is no guarantee that the river, if now improved, would remain in a state of efficiency, but would, instead, be closed again and require further expenditure.

The attention of Congress is again respectfully asked to this matter, and to the necessity of some general law to protect from injury and obstructions all navigable waters under the control of the United States, and for the improvement of which Congress has already made or may hereafter see fit to make appropriations.

This river throughout its whole extent forms a part of the international boundary, and that portion of it for which improvements are projected lies within the collection-district of Passamaquoddy, the nearest port of entry being at Calais, Me.

The light-house nearest thereto is at Dochet's Island, in Saint Croix River, about 8 miles below Calais, and the nearest fort is Fort Sullivan, at Eastport, Me., about 30 miles below Calais.

The following information in regard to the revenue and commerce of the port of Calais, for the year ending December 31, 1876, has been furnished by the United States deputy collector of customs, viz:

Amount of revenue collected, about $14,000.

Vessels arrived, 1,126 coastwise and 44 foreign; vessels cleared, 1,100 coastwise and 70 foreign.

Vessels built, 5, aggregating 3,534.05 tons.

Vessels owned and hailed from Calais, 93, aggregating 12,774 tons.

Money statement.

July 1, 1876, amount available	$34,185 58
July 1, 1877, amount expended during fiscal year	185 58
July 1, 1877, amount available	34,000 00
Amount (estimated) required for completion of existing project	40,000 00

A 2.

IMPROVEMENT OF MACHIAS RIVER, MAINE.

The following appropriations have been made for the improvement of this river, viz:

By act of Congress approved March 3, 1873	$12,000 00
By act of Congress approved June 23, 1874	10,000 00
By act of Congress approved March 3, 1875	10,000 00
Total	32,000 00

The foregoing appropriations have been made on an estimate submitted in my report of December 14, 1872, to the Department on the survey of this river, made with a view to its improvement, which estimate is as follows, viz:

1. Opening a channel from the draw-bridge up to Machias Falls, at the head of navigation, (a distance of about 3 miles,) so as to have a depth of 6 feet at mean low-water (giving 19.3 feet at mean high-water) for a width of 150 feet, requiring the excavation, of 65,500 cubic yards of slabs, edgings, sawdust, &c., at 50 cents	$32,750 00
2. The removal of Middle Rock, lying in front of the wharves at Machias, to a depth of 1 foot below the plane of mean low-water, requiring 2,095 cubic yards of excavation, at $5 per cubic yard	10,475 00
Adding for engineering expenses and other contingencies, say	4,775 00
Total	48,000 00

In the prosecution of this work it has been deemed advisable to modify the project first submitted (as above) by diminishing the proposed channel to a width of 100 feet, except at the bends, and not extending the excavation of Middle Rock to a greater depth than one-half a foot below the plane of mean low-water. By this modification the estimate has been reduced as follows, viz:

1. The removal of Middle Rock, 1,350 cubic yards, at $6.75 per cubic yard *in situ*, the price contracted for under the appropriation of March 3, 1873	$9,112 50
2. 17,840 cubic yards of dredging on shoal between the Middle Ground and Middle Rock above, together with a shoal next above draw-bridge, completed in July, 1875, at 75 cents per cubic yard *in situ*, the price contracted for under the appropriation of June 23, 1874, and with unexpended balance of former appropriation	10,704 00
3. 15,150 cubic yards of dredging at and near the Middle Ground, contracted for May 13, 1875, by Mr. Augustus R. Wright, under the appropriation of March 3, 1875, at 45 cents per cubic yard measured *in situ*, the same having been completed in November, 1876	6,817 50
Labor, contingencies, &c	5,366 00
Total	32,000 00

Which is the amount that has already been appropriated by Congress for this work.

As the shoals in this river have been caused chiefly by slabs, edgings, and sawdust, thrown into the river from the saw-mills at and above Machias Falls, they will of course continue to be formed so long as the mills shall be permitted, as at present, to throw their "waste" into the river; so that the improvement of the shoals now completed will probably be only temporary in its efficiency. But, if otherwise, it is believed that their improvement will fully answer the wants of the commerce of this river.

It is therefore recommended that no further appropriation be made for this work.

It is respectfully recommended that the attention of Congress be called to this matter, as well as to that of the Saint Croix River, with a view to protecting from injury and obstruction, by suitable legislation, these and all other navigable waters under the control of the United States, for the improvement of which appropriations have been or hereafter may be made by the United States Government.

The town of Machias, where the above-described improvements have been made, is situated at the head of navigation of Machias River, about 6 miles above Machiasport, at its mouth.

The nearest light-house is on Avery's Rock, at the head of Machias Bay, about 4 miles below Machiasport.

The following information in regard to the commerce and revenue of the port of Machias, for the year ending December 31, 1876, has been furnished by the collector of customs at that place, viz:

Value of imports	$415 00
Value of exports	$102,455 00
Number of arrivals from foreign ports	12
Number of departures for foreign ports	174
Number of arrivals from domestic ports	120
Number of departures for domestic ports	9
Revenue collected from all sources	$3,096 00

In addition to the above there were probably 600 arrivals and departures of vessels under license that did not report at the custom-house.

Number of vessels built during the year	10
Of a total tonnage of	4,033.61

Money statement.

July 1, 1876, amount available	$9,350 50
July 1, 1877, amount expended during fiscal year	9,350 50

A 3.

IMPROVEMENT OF PENOBSCOT RIVER, MAINE.

The work that has been projected for the improvement of this river consists—

1. In straightening and widening its channel through the several shoals and bars at Bangor, and below for a distance of three and a half miles, so as to have a width of not less than 200 feet and a depth of not less than 11 feet at low-water (or 25 feet at high-water) in the lowest stages of the river, giving about 14 feet of water at low-water in its ordinary stages.

2. In breaking up and removing all the sunken rocks in the harbor of Bangor down to the level of the general bed of the river near them, including Independence Rock, Gulliver's Rock, the ledge near steamboat-wharf, and those near Dole's planing-mill wharf; also Green's Pier and Green's Pier Ledge, and a ledge outside of it.

The following appropriations have been made by Congress to date for the improvement of this river, viz:

By act approved July 11, 1870	$15,000 00
By act approved March 3, 1871	50,000 00
By act approved June 10, 1872	40,000 00
By act approved March 3, 1873	20,000 00
By act approved June 23, 1874	20,000 00
By act approved March 3, 1875, which provides that $10,000 of this amount shall be expended at or near Bucksport Narrows, for which no project or estimate had been made	25,000 00
By act approved August 14, 1876, which provides that $4,000 of the amount shall be expended at or near the "Narrows" of said river at Bucksport	10,000 00
Total	180,000 00

Of which amount, $14,000 is chargeable to improvements at or near Bucksport Narrows, (not estimated for,) leaving only $166,000 available for the improvement of the river at and near Bangor, (above Hampden,) for which estimates have been submitted, amounting (as shown in the last annual report) to $172,000, leaving still necessary to be appropriated for completing all the works projected for the improvement of this river at and near Bangor, $6,000.

Of the total amount appropriated as above, (to wit $180,000,) there had been expended, on the 1st July, 1876—

For improving the river at and near Bangor	$114,955 72
And at and near Bucksport the sum of	10,000 00
Leaving, then, available for improvements at and near Bangor	45,044 28

The progress made in the improvement of this river, up to the 1st of July, 1876, was as follows:

I. AT AND NEAR BANGOR.

Independence Rock, Gulliver's Rock, and the ledges near steamboat wharf, near Dole's planing-mill wharf, and near (outside) Green's Pier, were all entirely removed; and the removal of Green's Pier and Green's Pier Ledge, (containing 466 cubic yards,) nearly completed, only about 120 cubic yards of the ledge remaining to be removed.

Under an unfinished contract, made May 27, 1870, with Mr. A. Boschké, about 20,000 cubic yards of dredging was done in 1870-'71 at the first and second bars near Bangor. Under a contract, made May 31, 1873, with Messrs. Curtis, Fobes & Co., of Portland, Me., about 25,000 cubic yards of dredging was done, whereby the channels at bars Nos. 2 and 3 were opened to the projected width and depth, and a shoal near Green's Pier was removed. Under a contract, made August 29, 1874, with Messrs. Curtis, Fobes & Co. for 25,000 cubic yards, more or less, of dredging in Bangor Harbor, 8,222 cubic yards of the dredging was done; and a contract had been made with Mr. Augustus R. Wright, of Geneva, N. Y., for 40,000 cubic yards, more or less, of dredging in Bangor Harbor, at 50 cents per cubic yard, measured *in situ*.

During the fiscal year ending June 30, 1877, the following additional work has been done, to wit:

The removal of Green's Pier Ledge was completed early in August, 1876, by Mr. George A. Bailey, under his contract of June 21, 1873. Under the contract made August 24, 1874, with Messrs. Curtis, Fobes & Co., 12,468 cubic yards of additional dredging was done in Bangor Harbor, making a total of 20,690 cubic yards on the completion of that contract in November, 1876. Under the contract made May 13, 1875, with Mr. Augustus R. Wright, for 40,000 cubic yards, more or less, of dredging in Bangor Harbor, he commenced operations on the 17th of July, and continued them until the 15th of November, when, on account of freshets and ice, they were suspended until the 24th of May, when they were resumed for the season. Up to the 1st of July, 1877, about 21,000 cubic yards of dredging has been done, leaving about 18,000 cubic yards yet to be done under this contract, in total completion of all the projected dredging; which, it is probable, will be done the present season.

In the dredging operations of 1875 and 1876, several sunken ledges were discovered in and near the new channel at Bangor, to excavate which to the same depth as that of the channel, (viz, 11 feet below the plane of low-water in the lowest stages of the river,) will require the breaking up and removal of about 222 cubic yards of ledge above that plane, the estimated cost of which is $12,000.

The unexpended balance of the appropriation of March 3, 1875, (viz, $13,209.30,) it is believed will complete all the projected dredging under the contract made May 13, 1875, with Mr. Wright. So that the only work that now remains to be done for completing the improvement of this river at and near Bangor is the removal of the sunken ledges recently discovered in and near the new channel at Bangor.

Under the appropriation of $6,000 made by act of August 14, 1876, now available for the improvement of this river at and near Bangor, a contract, dated May 29, 1877, was made with Mr. Gardner Floyd, of Portland, Me., for the removal of 140 cubic yards, more or less, of the sunken ledge, the same to be completed on or before the 20th of November, 1877; leaving about 82 cubic yards to be removed hereafter, should an appropriation be made therefor by Congress.

II. AT AND NEAR BUCKSPORT NARROWS.

By the act of March 3, 1875, making an appropriation of $25,000 for the improvement of Penobscot River, it was provided that $10,000 of it should be expended "at or near Bucksport Narrows," 18 miles below Bangor. This appropriation was applied to the partial removal of the shoal known as the Middle Ground, in front of the town of Bucksport. This shoal had in some places but 4 feet of water at mean low-water, and was a serious obstruction to navigation. Under a contract made July 16, 1875, with Messrs. Curtis, Fobes & Co., of Portland, Me., the lowest of two bidders, the upper portion of this shoal was removed in 1875 to a depth of 12 feet at mean low-water, or 22.3 feet at ordinary high-water.

Under the act of August 14, 1876, by which an additional sum of $4,000 is to be applied to the improvement of the river "at or near the Narrows" at Bucksport, a contract, dated June 1, 1877, has been made with Mr. Augustus R. Wright for 12,000 cubic yards, more or less, of dredging on the remaining part of the Middle Ground, so as to have a depth of not less than 8 feet at mean low-water, the work to be completed not later than the 30th day of November, 1877.

The following information in regard to the revenue and commerce of the port of Bangor, for the year ending December 31, 1876, has been furnished by the United States collector of customs at that place, viz:

Amount of revenue collected	$6,670 00
Amount of imports	10,108 00
Amount of exports	141,904 00

Number of arrivals of vessels about 2,500; departures the same.

Arrivals of foreign vessels from foreign ports	17
Clearances of foreign vessels for foreign ports	17
Arrivals of American vessels from foreign ports	12
Clearances of American vessels for foreign ports	42
Number of vessels built	3
Aggregate tonnage	711

Abstracts of proposals received and contracts made during the past year are hereto appended.

Money statement.

July 1, 1876, amount available	$45,044 28	
Amount appropriated by act approved August 14, 1876	10,000 00	
		$55,044 28
July 1, 1877, amount expended during fiscal year	31,834 98	
July 1, 1877, outstanding liabilities	925 00	
		32,759 98
July 1, 1877, amount available		22,284 30
Amount (estimated) required for completion of existing project		6,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		6,000 00

Abstract of proposals received May 26, 1877, for improvement of Penobscot River, Maine.

Number for reference.	Bidders.	Nature and location of work.	Price per cubic yard.	Remarks.
1	Gardner Floyd, Portland, Me......	Rock-excavation in the harbor of Bangor, Me.	$39 75	As measured in its bed.
2	George W. Townsend, Boston, Mass		40 00	
3	Augustus R. Wright, Portland, Me	Dredging at Bucksport, Me	30	As measured in the scows.

Abstract of contracts made during the fiscal year ending June 30, 1877, for the improvement of Penobscot River, Maine.

Date of contracts.	Contractors.	Nature and location of work.	Price per cubic yard.	Remarks.
1877. May 29	Gardner Floyd, Portland, Me	Rock-excavations in the harbor of Bangor; 140 cubic yards, more or less.	$39 75	As measured in its bed.
June 1	Augustus R. Wright, Portland, Me	Dredging at Bucksport, Me.; 12,000 cubic yards, more or less.	30	As measured in the scows.

A 4.

IMPROVEMENT OF BELFAST HARBOR, MAINE.

In compliance with the act of Congress approved March 3, 1875, "making appropriations for the repair, preservation, and completion of certain public works on rivers and harbors, and for other purposes," a survey of this harbor was made under my direction in July and August, 1875, with a view to its improvement, the report on which accompanies my annual report, in which the following facts are stated, viz:

1. That the harbor itself is well protected from all winds except those from the southeast; and that to render it safe from these also would require the construction of a breakwater or breakwaters between McGilvery's ship-yard and Patterson's Point, a distance of about half a mile.

2. That there is a shoal on the west side of the harbor, which extends from McGilvery's ship yard up to the ledge in front of Lane's wharf, a distance of about five-eighths of a mile. This shoal lies in front of the Boston, Portland, and Bangor steamboat wharves, and in places has but 6 feet of water over it at mean low-water, thereby being a serious obstruction to that part of the harbor.

3. That there is an extensive sunken ledge, which projects 160 feet into the harbor in front of Lane's wharf, having over its shoalest part but 3.4 feet of water at mean low-water, or 13.1 feet at ordinary high-water, the mean rise and fall of the tides being 9.7 feet. This ledge is about one-third of a mile below the bridge at the head of the harbor, and, projecting into the harbor, as it does, it necessarily endangers vessels lying or moving near it.

To so improve this harbor as to afford a safe anchorage for shipping in all storms, and so that it shall have a suitable depth for the steamers

and vessels that touch and lie there in all stages of the tide, would require the following work to be done, viz:

A. The construction of a riprap stone breakwater or breakwaters between McGilvery's ship-yard and Patterson's Point. The plan now proposed for this work consists in building one breakwater out from McGilvery's wharf in a direction nearly northeast, for a length of 1,500 feet, and a second one out from Patterson's Point (on the easterly side of the harbor) in a direction nearly south-southwest for a distance of 900 feet, thereby leaving an entrance 800 feet in width. By this arrangement the effect of the southeast gales would be very limited in force and extent, and would be felt on the easterly side only of the harbor, which is not used for anchorage-ground. This work would require about 200,000 tons of stone, the estimated cost of which (including engineering and other incidental expenses) is $310,000.

B. The excavation by dredging of the shoal between McGilvery's ship-yard and the ledge, to a depth of 12 feet at mean low-water, which would require about 115,000 cubic yards of dredging, the estimated cost of which (including contingencies) is $25,000.

C. The removal of the sunken ledge in front of Lane's wharf, outside of the proposed line, as shown on the accompanying drawing, to a depth of 7 feet at mean low-water, which would require the removal of about 420 cubic yards of ledge, at an estimated cost of $12,000. To excavate this ledge to a greater depth, and over a more extended area, would involve a greater expense than would be justified by the benefits gained.

In consideration, also, of the great cost of the breakwaters on the plan proposed, it might be deemed advisable to build only the one extending out from the westerly shore, the estimated cost of which (including engineering and other incidental expenses) is $195,000, but this would give only a partial protection to the harbor, much better, however, than none.

The extent to which the commerce of the country would be promoted by the improvement of this harbor, as now proposed, is stated in the accompanying letter from the United States deputy collector of customs at that port.

RECAPITULATION OF ESTIMATES.

For breakwater between McGilvery's ship-yard and Patterson's Point....	$310,000 00
For removal of shoal above ship-yard..........	25,000 00
For removal of sunken ledge to a depth of 7 feet below mean low-water, say	12,000 00
Total..........	347,000 00

By the act of Congress approved August 14, 1876, "making appropriations for the construction, repair, preservation, and completion of certain public works on rivers and harbors, and for other purposes," the sum of $5,000 was appropriated for the improvement of this harbor. Information from the Chief of Engineers was received in Department letter of May 1, 1877, that the expenditure of this amount had been authorized by the Secretary of War. Owing to the small amount appropriated it has been deemed advisable to apply it to the partial removal of the sunken ledge abreast of Lane's wharf, to a depth of 7 feet at mean low-water, over so much of its area as the amount available will allow. Proposals were invited for this work, and in response thereto three bids were received, as stated in the accompanying abstract of the same, the lowest of which being that of Mr. James M. Andrews, of Biddeford, Me., at $20 per cubic yard as measured in its bed, with whom a contract has been made for completing the work on or before the 20th of November, 1877.

For completing the removal of this ledge and the shoals below to the projected depth will require an additional appropriation of $30,000, which can be profitably expended during the next fiscal year.

The following-named papers are hereto appended, viz:

1. Abstract of proposals received.
2. Abstract of contracts made.
3. Copy of letter from United States deputy collector of customs.

Money statement.

Amount appropriated by act approved August 14, 1876	$5,000 00
July 1, 1877, amount expended during fiscal year	9 00
July 1, 1877, amount available	4,991 00
Amount (estimated) required for completion of existing project	342,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	30,000 00

Abstract of proposals received May 26, 1877, for the improvement of Belfast Harbor, Maine.

Number for reference.	Bidders.	Nature and location of work.	Price per cubic yard.	Remarks.
1	James M. Andrews, Biddeford, Me	For removing sunken ledge off Lane's wharf, Belfast Harbor, Maine.	$20 00	As measured in its bed.
2	Gardner Floyd, Portland, Me		36 50	
3	Isaac Hamilton, Portland, Me		39 00	

Abstract of contracts made during the fiscal year ending June 30, 1877, for the improvement of Belfast Harbor, Maine.

Date of contract.	Contractor.	Nature and location of work.	Price per cubic yard.	Remarks.
June 23, 1877	James M. Andrews, Biddeford, Me.	For removing sunken ledge off Lane's wharf, Belfast Harbor, Maine.	$20 00	As measured in its bed.

COMMERCIAL STATISTICS.

CUSTOM-HOUSE, BELFAST, ME.,
Collector's Office, June 12, 1877.

SIR: Your letter of yesterday was duly received at this office, and in answer to your first question I respectfully state that upon merchandise entered and landed at this port, in the year ending December 31, 1876, there were collected duties amounting to $8,015.10. (Duties collected on goods landed at other ports in this district are not included in this statement.)

In answer to your second inquiry, I will say that our export records show but $3,008 in value exported from this port in 1876; our imports, in value, for the same time, being $28,158.14; our imports consisted principally of gypsum and molasses, being 1,540 tons of gypsum and 117,755 gallons of molasses.

In answer to your third and last inquiry, I must say that but two vessels were built at this port in 1876, aggregating 2,131.64 tons. That, however, from certain causes, was not the usual amount of ship-building annually done here.

There were, in 1876, 16 foreign arrivals to this port, and the same number of foreign clearances.

We have no data at this office from which to give the number of coastwise arrivals, as the most of our coasting-trade is such as requires no report to be made here of arrivals or clearances, but parties who are engaged largely in that business estimate from 6 to 10 arrivals daily through the most of the year.

Very respectfully,

MARSHALL DAVIS,
Special Deputy Collector.

General GEORGE THOM,
Corps of Engineers U. S. A.

A 5.

IMPROVEMENT OF THE KENNEBEC RIVER, MAINE.

The following appropriations have been made by Congress for the improvement of this river, viz.:

By act approved June 23, 1866	$20,000 00
By act approved March 2, 1867	30,000 00
Allotted under act approved April 10, 1869	15,000 00
By act approved July 11, 1870	15,000 00
By act approved March 3, 1871	15,000 00
By act approved June 10, 1872	8,000 00
By act approved March 3, 1873	12,000 00
By act approved June 23, 1874	12,000 00
By act approved March 3, 1875	15,000 00
Total	142,000 00

All the improvements projected for this river above Richmond, Me., were completed prior to June 30, 1874, as described in my annual report for the fiscal year ending that date, whereby a safe and unobstructed channel not less than 100 feet in width and 10 feet in depth at mean low-water, or 15½ feet at mean high-water in its low summer stages, had been completed from Richmond up to Gardiner, a distance of 11 miles; and thence to Augusta, a distance of 7 miles, a channel 100 feet in width and not less than 6½ feet in depth at low-water, or 11 feet at high-water, in its lowest summer stages. This improvement included the removal of a very dangerous ledge known as Nehumkeg Rock (between Richmond and Gardiner) to a depth of 12 feet below mean low-water; and, below Richmond, Half-Tide Rock and three other sunken ledges have been removed from the channel at "The Narrows," whereby all the work contemplated for the improvement of this river has been completed with the exception of the removal of Dry Rock in "The Narrows."

On the 6th of May, 1875, a contract was made with Mr. Isaac Hamilton, of Portland, Me., the lowest of five bidders, for removing Dry Rock (containing about 1,775 cubic yards) at $15 per cubic yard, as measured in its bed, so as to have over it a depth of 12 feet at mean low-water. Work was commenced under this contract on the 2d of June, 1875, and was continued up to the 20th of November, 1875, (when it was suspended on account of freshets and ice,) and again resumed on the 2d of June, 1876, and continued up to the 8th of November, 1876, when about 1,100 cubic yards had been removed. It was then again suspended for the winter on account of freshets and ice, and was resumed on the 30th of May, 1877. Up to July 1, 1877, about 1,230 cubic yards were removed to the required depth, leaving only 545 cubic yards to be removed. This work will probably be completed not later than the 1st of October, 1877.

The funds now available are sufficient for completing this, the only remaining work to be done, so that no further appropriations will be needed.

These improvements, as above described, are located in the collection-district of Bath, Me., in which Bath (30 miles below Augusta) is the only port of entry.

Fort Popham is at the mouth of Kennebec River, about 45 miles below Augusta, and the United States "Kennebec Arsenal" is located at Augusta.

Seguin and Pond Island light-houses are near the mouth of Kennebec River.

The following information in regard to the commerce and revenue of

the port of Bath, for the year ending December 31, 1876, has been furnished by the United States collector of customs at that port:

Amount of revenue collected	$15,636 57
Value of exports	$155,767 00
Value of imports	$39,948 00
Arrivals of vessels from foreign ports	10
Arrivals of vessels coastwise	2,512
Departures of vessels for foreign ports	19
Departures of vessels coastwise	2,546
Number of vessels built in the district	46
Aggregate tonnage of same	31,923 67

Money statement.

July 1, 1876, amount available		$27,815 33
July 1, 1877, amount expended during fiscal year	$11,125 77	
July 1, 1877, outstanding liabilities	7,200 00	
		18,325 77
July 1, 1877, amount available		9,489 56

A 6.

IMPROVEMENT OF PORTLAND HARBOR, MAINE.

The following appropriations have been made by Congress for the improvement of this harbor, viz:

By act approved June 23, 1866		$105,111 05
By act approved July 11, 1870		10,000 00
By act approved March 3, 1871		40,000 00
By act approved June 10, 1872		45,000 00
By act approved March 3, 1873		50,000 00
By act approved June 23, 1874		20,000 00
By act approved March 3, 1875		20,000 00
Total		290,111 05
Amount expended up to July 1, 1876	$245,542 07	
Amount expended during the fiscal year ending June 30, 1877	1,638 88	
		247,180 95
Amount available July 1, 1877		42,930 10

Up to the 1st of July, 1876, the following work had been done for the improvement of this harbor, viz:

1. The breakwater extended for a length of 217 feet, and a granite pier built at its outer extremity, and 950 linear feet of capping placed upon the breakwater, in completion of same.

2. A channel dredged through the Middle Ground Bar to a width of 500 feet and to a depth of 21 to 22 feet at mean low-water, or 31 feet at ordinary high-water.

3. A channel dredged through the "spit" in front of the Grand Trunk Railway wharves to a width of 100 feet at its inner end and 200 feet at its outer end, and to a depth of 20 feet at mean low-water.

4. A channel dredged in Back Bay from Tukey's bridge up to the "stone-shed wharves" to a width of 100 feet and a depth of 8 feet at mean low-water.

5. A sunken wreck removed from the main ship-channel between Forts Preble and Scammel.

6. The foundation of the oldest portion of the breakwater repaired throughout its whole extent where necessary.

7. All the projected dredging in front of the Grand Trunk Railway wharves has been completed to a depth of 20 feet at mean low-water, and all that in front of the harbor-commissioners' line, from Atlantic wharf up to Merrill's wharf, to a depth of about 16 feet at mean low-water.

8. Deepening the dock at Custom-House wharf by 2,932 cubic yards of dredging, the same having been authorized by the Department upon the request of the honorable Secretary of the Treasury.

All the work that has been projected for the improvement of this harbor has been completed, with the exception of the dredging outside the harbor-commissioners' line above Merrill's wharf, for the completion of which the funds now available are sufficient, so that no further appropriation is needed for this harbor.

In regard to the dredging that remains to be done above Merrill's wharf outside the harbor-commissioners' line, it has been decided to defer the work until Brown's, Boston and Maine, (formerly Smith's,) Hobson's, and other wharves which project beyond the harbor-commissioners' line shall have been cut off up to that line, for the reason that this work of improving the harbor in front of that line was initiated and recommended, and all the appropriations made therefor in 1873, 1874, and 1875, aggregating $90,000, have been asked for with the understanding that those projecting wharves should first be removed in order to make the contemplated improvement effective and lasting; for so long as those wharves are permitted to project outside the harbor-commissioners' line, so long will the eddies and shoals continue to exist above and below those wharves.

The above-described works are situated in the collection-district of Portland and Falmouth, Me.

The following information in regard to the commerce and revenue of the port of Portland and Falmouth for the year ending December 31, 1876, has been furnished by the United States collector of customs at that port:

Amount of revenue collected	$321,994 49
Amount of imports	14,963,745 00
Amount of exports	18,162,505 00

	Number.	Tons.	Crew.
Arrivals of vessels	1,089	815,126	18,658
Clearances of vessels	1,184	893,999	20,028

Number of vessels built in the district	20
Aggregate tonnage of same	9,590

Money statement.

July 1, 1876, amount available	$44,568 98
July 1, 1877, amount expended during fiscal year	1,638 88
July 1, 1877, amount available	42,930 10

A 7.

IMPROVEMENT OF RICHMOND'S ISLAND, MAINE.

This work consists in making a harbor of refuge by means of a stone breakwater connecting the island with the main land, the length of the

breakwater to be about 2,000 feet, with an average thickness of 30 feet and a height of 13 feet above mean low-water.

In my report to the Department, dated May 10, 1867, the following estimate of the cost of this breakwater was submitted:

68,000 tons of rubble-stone, at $1.25	$85,000 00
Adding 10 per cent. for contingencies	8,500 00
Total	93,500 00

A capping for this work was not then estimated for, on account of the great increase of cost, but, as then stated, should it hereafter be found necessary in order to resist the action of the sea, which is not probable, it can then be added.

The following appropriations have been made by Congress for this work, viz:

By act approved June 10, 1872	$20,000 00
By act approved March 3, 1873	60,000 00
By act approved March 3, 1875	15,000 00
Total	95,000 00

Under these appropriations five separate contracts have been made from time to time (as specified in the annual report for the fiscal year ending June 30, 1876) for furnishing stone for this breakwater, by which 58,000 tons have been furnished and placed upon the work. To finish it as originally projected will require about 10,000 tons more, the estimated cost of which, including contingencies, is $15,000, thereby making the total cost of the work completed $110,000, which is $16,500 in excess of the original estimate. This excess is owing to the greater cost of the stone than was originally estimated, the quantity being the same.

Money statement.

Amount (estimated) required for completion of existing project	$15,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	15,000 00

A 8.

IMPROVEMENT OF KENNEBUNK RIVER, MAINE.

By an act of Congress approved July 11, 1870, the sum of $5,000 was appropriated for the improvement of this river. No report or estimate had previously been made upon which this appropriation was based. But an investigation showed, as stated in my report to the Department dated August 16, 1870, that about seventeen years previously stone piers had been built on each side of the river, at its mouth, for the purpose of improving the course and depth of the channel at the entrance into the river; that on the outer end of the eastern pier a wooden light-house had been built, and was afterward destroyed by storms; and that a wharf had been built on the left (eastern) shore of the river about one-eighth of a mile above its mouth for the security of vessels while awaiting tides and storms. It was also ascertained that the wings or returns connecting these stone piers with the banks, which were built of timber, had been destroyed by storms, and that the Government wharf was also much in want of repairs, but that the most necessary work to be done under the appropriation was the

rebuilding of the eastern wing with stone, so as to prevent the flow of sand from the outside into the channel of the river. This wing was completed December 15, 1870, for a length of 168 feet under a contract made October 12, 1870, with Messrs. Albert Blaisdell and Joseph S. Bailey, of Portland, Me., for the sum of $21.35 per linear foot. Under the same appropriation some repairs were made on the main eastern pier as well as upon the Government wharf.

With a view to repairing the western stone pier and rebuilding with stone the wing connecting it with the shore, the estimated cost of which was $5,000, an additional appropriation was made therefor by act of Congress approved March 3, 1871. Under this appropriation the western wing was completed in August, 1871, for a length of 166⅓ feet, under a contract made May 5, 1871, with Mr. Charles H. Bragdon, of Biddeford, Me., for $18.62 per linear foot. Under the same appropriation, the much-needed repairs were made, with hired labor, upon both stone piers and upon the Government wharf above, which were entirely completed in August, 1872, whereby the appropriations for this river were exhausted.

By an act of Congress approved June 23, 1874, a survey of this river was called for, with a view to its further improvement. A report on this survey, dated December 2, 1874, accompanied my annual report for the year ending June 30, 1875, in which an estimate of $5,000 was submitted for the improvement of this river from its mouth up to the drawbridge at Kennebunkport, a distance of 1⅛ miles, for items as follows, viz:

1. Removal of 4,200 cubic yards of mud and clay at Mitchell's Point, at 75 cents per cubic yard	$3,150 00
2. Removal of 1,300 cubic yards of sand, sods, and logs at the "Wading Place," at $1 per cubic yard	1,300 00
Contingencies, say	550 00
Total	5,000 00

By the river and harbor act of August 14, 1876, the sum of $5,000 was appropriated for this work, which became available therefor under authority contained in Department letter of May 1, 1877. Proposals were at once invited for the projected dredging in this river, in response to which two bids were received, as stated in the accompanying abstract of same, and a contract was made with Messrs. George C. Fobes & Co., of Portland, Me., the lowest bidder, at 50 cents per cubic yard, the same to be completed on or before the 30th of September, 1877.

This river lies within the collection-district of Kennebunk, of which Kennebunk is the port of entry.

The following information as to the revenue and commerce of the port of Kennebunk, Me., for the year ending December 31, 1876, has been furnished by the United States collector of customs at that place, viz:

Amount of revenue collected, $1,618.89. Number of arrivals and departures of foreign and domestic vessels estimated at 150. Number of vessels built, 10, with an aggregate otnnage of 7,068.51, the largest of which measured 2,117.41. At the present time some 10 vessels are being built.

Abstracts of proposals received and contracts made during the past year are hereto appended.

Money statement.

Amount appropriated by act approved August 14, 1876	$5,000 00
July 1, 1877, amount expended during fiscal year	8 00
July 1, 1877, amount available	4,992 00

Abstract of proposals received May 26, 1877, for improvement of Kennebunk River, Maine.

Numbers for reference.	Bidders.	Nature and location of work.	Price per cubic yard.	Remarks.
1	George C. Fobes & Co., Portland, Me.	Dredging at Wading Place and Mitchell's Point Shoal, 5,000 cubic yards, more or less.	$0 50	As measured in the scows.
2	Augustus R. Wright, Portland, Me.		60	

Abstract of contracts made during the fiscal year ending June 30, 1877, for the improvement of Kennebunk River, Maine.

Date of contract.	Contractors.	Nature and location of work.	Price per cubic yard.	Remarks.
June 7, 1877	George C. Fobes & Co., Portland, Me.	Dredging at Wading Place and Mitchell's Point Shoal, 5,000 cubic yards, more or less.	$0 50	As measured in the scows.

A 9.

IMPROVEMENT OF COCHECO RIVER, NEW HAMPSHIRE.

This river, in its lowest summer stage, is navigable with 6 feet of water at mean low-water, or 13½ feet at ordinary high-water from the harbor of Portsmouth, N. H., up to the Lower Narrows, which place is about 10 miles above Portsmouth, and 1½ miles below the bridge at the head of navigation in Dover, N. H. At the Lower Narrows and above, its navigation has hitherto been much obstructed by ledges, bowlders, and shoals, having only from six inches to 2 feet of water over them at mean low-water. The average rise and fall of the tide is $6\frac{8}{10}$ feet at the Lower Narrows, and less above.

The project for the improvement of this river consists in making a channel not less than 40 feet in width and 4 feet in depth at mean low-water, from the foot of the Lower Narrows up to the Packet Landing, the total estimated cost of which, as now revised, is $90,000.

The following appropriations have been made therefor by Congress, viz:

By act approved March 3, 1871	$10,000 00
By act approved June 10, 1872	10,000 00
By act approved March 3, 1873	10,000 00
By act approved June 23, 1874	10,000 00
By act approved March 3, 1875	25,000 00
By act approved August 14, 1876	14,000 00
Total	79,000 00

Under these several appropriations, contracts have been made from time to time as specified in my last annual report, whereby the following progress has been made up to this date, viz:

1. The channel has been opened through the ledge at the Upper Nar-

rows, for a length of 430 feet, and to a width of 40 feet, and a depth of 4 feet at mean low-water, requiring 1,255 cubic yards of rock excavation.

2. The channel has been opened through the ledge and shoal next above the Upper Narrows, for a length of 260 feet, and to a width of 40 feet, and a depth of 4 feet at mean low-water, requiring 1,108 cubic yards of excavation of ledge, bowlders, clay, &c.

3. The channel has been opened by dredging from Gulf Shoal up to the Packet Landing, in places where necessary, to the same width and depth as at the Upper Narrows, requiring 7,108 cubic yards of dredging for its accomplishment.

4. The channel has been nearly completed at and near the Lower Narrows, by the removal of about 600 cubic yards of sunken ledge and bowlders; and numerous scattered bowlders which were dangerous obstructions to navigation have been removed from the channel at Trickey's Shoal, and Clement's Point Shoal above; a portion of which have been removed during the past year, by employing a submarine party provided with vessel and crew, steam-drill, and hoisting machinery.

Under the appropriation of $14,000, made by the river and harbor act of August 14, 1876, proposals were invited for doing all the *dredging* now required for completing the projected basin at the Packet Landing, as well as for dredging at Clement's Point Shoal, and below. A contract for this work was made June 12, 1877, with the Atlantic Dredging Company of Brooklyn, N. Y., the lowest of three bidders, at 49 cents per cubic yard, as measured in its bed, for the dredging near Packet Landing; and at 97 cents per cubic yard, as measured in the scows, for the dredging at Clement's Point Shoal, and below. The same to be completed on or before September 30, 1877.

Operations have been commenced under this contract, and it is probable that they will be completed within the time called for.

All the work now projected for this river has been provided for and taken in hand, with the exception of the excavation of a channel through the ledge at Gulf Shoal, next below the Upper Narrows, which is indispensably necessary for the effectual and permanent improvement of this river, as well as to give to the work already done its full value.

This shoal is 160 feet in width, and will require the excavation of about 500 cubic yards of ledge, bowlders, &c., the estimated cost of which, at $20 per cubic yard, is	$10,000 00
Adding for contingencies, say	1,000 00
Total	11,000 00

Which is the additional amount now required for completing all the work necessary for the improvement of the river.

An attempt has been made to ascertain the nature and extent of the commerce on this river, but to no purpose. It has, however, greatly increased during the last two years, owing to the improvements already made in its navigation; and arrangements are being perfected for a much greater increase of it, by the building of new wharves and store-houses, with a view to direct importation of coal, lime, and other articles, which have hitherto been brought up in limited quantity, on barges, on which they were transshipped at Portsmouth, N. H.

Abstracts of proposals received and contracts made during the past year are hereto appended.

Money statement.

July 1, 1876, amount available	$2,881 56	
Amount appropriated by act approved August 14, 1876	14,000 00	
		$16,881 56
July 1, 1877, amount expended during fiscal year	5,046 26	
July 1, 1877, outstanding liabilities	607 22	
		5,653 48
July 1, 1877, amount available		11,228 08
Amount (estimated) required for completion of existing project		11,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		11,000 00

Abstract of proposals received May 26, 1877, for dredging in Cocheco River, New Hampshire

Numbers for reference.	Bidders.	Location and nature of work.	Price per cubic yard.	Remarks.
		DREDGING.		
1	Atlantic Dredging Company, of Brooklyn, N. Y.	Near Packet Landing, 10,000 cubic yards, more or less.	$0 49	As measured in the bed.
		Clement's Point Shoal and below, 2,000 cubic yards, more or less.	97	As measured in the scows.
2	George C. Fobes & Co., of Portland, Me.	Near Packet Landing, 10,000 cubic yards, more or less.	54	As measured in the bed.
		Clement's Point Shoal and below, 2,000 cubic yards, more or less.	1 75	As measured in the scows.
3	Augustus R. Wright, of Portland, Me.	Near Packet Landing, 10,000 cubic yards, more or less.	60	As measured in the bed.
		Clement's Point Shoal and below, 2,000 cubic yards, more or less.	2 50	As measured in the scows.

Abstract of contracts made during the fiscal year ending June 30, 1877, for the improvement of Cocheco River, New Hampshire.

Date of contract.	Contractor.	Nature and location of work.	Price per cubic yard.	Remarks.
		DREDGING.		
1877. June 12	Atlantic Dredging Company, of Brooklyn, N. Y.	*Above* the "Gulf," near Packet Landing, 10,000 cubic yards, more or less.	$0 49	As measured in the bed.
		Below the "Gulf," at Clement's Point Shoal and below, 2,000 cubic yards, more or less.	97	As measured in the scows.

A 10.

IMPROVEMENT OF MERRIMAC RIVER, INCLUDING THE HARBOR OF NEWBURYPORT, MASSACHUSETTS.

The project adopted for the improvement of this river consists in deepening its shoals by dredging and in removing sunken rocks from its channel, so that it shall have a depth of 12 feet at ordinary high-water, from its mouth in Newburyport Harbor, Massachusetts, up to

Haverhill, (a distance of 15 miles;) and thence for a distance of about 4 miles up through "the falls" a depth of 4 feet in the ordinary stages of the river; and for the improvement of Newburyport Harbor, in the removal of North and South Gangeway Rocks to a depth of 9 feet at mean low-water, the removal of "The Boilers" (sunken rocks near the city wharves) to a depth of 5 feet at mean low-water, and the removal of a sunken wreck.

The total estimated cost of all the work necessary for these improvements was $147,000, as specified in my last annual report, for which the following appropriations have been made by Congress, viz:

By act of July 11, 1870, for improvement of Merrimac River, Massachusetts	$25,000 00
By act of March 3, 1871, for improvement of Merrimac River above Haverhill, Mass	25,000 00
By act of June 10, 1872, for improvement of Merrimac River above Haverhill, Mass	25,000 00
By act of March 3, 1873, for improvement of Merrimac River, Massachusetts	25,000 00
By act of June 23, 1874, for continuing the improvement of Merrimac River, Massachusetts	10,000 00
By act of March 3, 1875, for improvement of Merrimac River, Massachusetts	12,000 00
Total	122,000 00
The amount that had been expended up to July 1, 1876, for improving this river and harbor was	111,539 46
Leaving then available the sum of	10,460 54

At that date the following work had been accomplished, to wit:

1. For the improvement of Newburyport Harbor.

The main (South) Gangeway Rock broken up and removed to a depth of 9 feet at mean low-water, and a commencement made upon the removal of North Gangeway Rock, and the wreck of the schooner Globe also broken up and removed, leaving yet to be done the removal of North Gangeway Rock and "The Boilers."

2. For the improvement of the river above Newburyport.

The channel completed at Hazeltine Rapids, Lower Falls, and Upper Falls, (above Haverhill, Mass.,) so as to be navigable through the falls, for a depth of 4 feet, in all stages of the river, except in an unusually low stage, resulting from shutting off the water at the Lawrence mills on Sundays and at night.

Shoals dredged and sunken bowlders removed from the channel at and near Rock's Bridge, (6½ miles below Haverhill,) including Little Currier Rock above and Petty Rock below the bridge, greatly improving this the most dangerous part of the river below Haverhill; some progress had also been made in the dredging for the improvement of Currier's Shoal, (about 5 miles below Haverhill.) In addition to the above, the following work has been done for the improvement of the river since the 1st of July, 1876, viz:

The channel has been opened by dredging for a width of 100 feet, to the projected depth, (viz, 12 feet at ordinary high-water,) at Currier's Shoal, (distant about 5 miles below Haverhill,) under a contract with Messrs. Curtis, Fobes & Co., of Portland, Me.; also to the same depth and for a width of 75 feet at the shoals near the head and foot of Sils-

by's Island, from 1 to 2 miles below Haverhill. The shoal between the two bridges at Haverhill has also been improved by dredging so as to have a channel 10 feet in depth at ordinary high-water, and numerous large bowlders have been removed from the channel at and near the falls above Haverhill.

The operations in this river were continued until the last of October, when they were suspended for the winter on account of freshets and ice.

The only work that remains to be done for the improvement of this river above Newburyport Harbor, as now projected, consists of the removal of some sunken rocks which obstruct the channel near the head of Silsby's Island. This can be done with the unexpended balance of the appropriation of March 3, 1875, now available therefor; and arrangements will be made to complete it at an early day, not later than the 1st of September next, by employing a submarine party, together with a vessel and crew, provided with suitable machinery, at a cost not to exceed $45 per day.

The following is the estimated cost of the completion of the work now projected for the improvement of Newburyport Harbor, to wit:

1. Completing the removal of North Gangeway Rock to a depth of 9 feet below mean low-water—say, 360 cubic yards, at $40 per cubic yard	$14,400 00
2. For breaking up and removing "The Boilers" to a depth of 5 feet at mean low-water—say, 352 cubic yards, at $25 per cubic yard	8,800 00
Adding for contingencies, say	1,800 00
Total	25,000 00

The following information in regard to the revenue and commerce of the port of Newburyport, Mass., for the year ending December 31, 1876, has been furnished by the United States collector of customs at that place, viz:

Amount of revenue collected	$91,649
Value of exports	79,032
Value of imports	201,342
Number of vessels entered from foreign ports	32
Number of vessels cleared for foreign ports	33
Number of vessels entered from domestic ports	442
Number of vessels cleared for domestic ports	376
Number of vessels built during the year	3
The aggregate tonnage of which was	3,069.4

Money statement.

July 1, 1876, amount available	$10,460 54
July 1, 1877, amount expended during fiscal year	9,209 44
July 1, 1877, amount available	1,251 10
Amount (estimated) required for completion of existing project	25,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	25,000 00

A II.

IMPROVEMENT OF SALEM HARBOR, MASSACHUSETTS.

The act of Congress approved June 10, 1872, "making appropriations for the repair, preservation, and completion of certain public works on rivers and harbors, and for other purposes," provided for a survey of this harbor with a view to its improvement. A survey of it, made in August and September, 1872, under my direction, showed that the following works were necessary, viz:

1. The excavation by dredging of a channel 1,730 feet long, 300 feet wide, and 8 feet deep at mean low-water, (giving 17.3 feet at mean high-water,) from deep water in to the entrance of South River. The estimated cost of which was as follows, viz:

(*a*) Excavating 36,000 cubic yards of mud, at 50 cents	$18,000 00
(*b*) Excavating 12,000 cubic yards of hard clay, at 90 cents	10,800 00
Adding for contingencies, say	3,200 00
Total	32,000 00
2. For constructing a sea-wall and breakwater for the protection and preservation of Long Point, as per estimate given in annual report of 1873.	23,000 00
Total	55,000 00

Upon the above estimates appropriations have been made by Congress as follows, viz:

By act approved March 3, 1873	$15,000 00
By act approved June 23, 1874	10,000 00
Total	25,000 00

Under the appropriation of March 3, 1873, a contract was made with Mr. Augustus R. Wright, of Geneva, N. Y., for dredging, at 44 cents per cubic yard, as measured in the scows, by which the channel was opened to the projected length and depth for a width of 160 feet.

Under the appropriation of June 23, 1874, a contract was made September 5, 1874, with Messrs. Curtis, Fobes & Co., of Portland, Me., the lowest of four bidders, for completing all the projected dredging at this place, at the following prices, viz:

(1.) Stiff clay intermixed with bowlders, at 35 cents per cubic yard, as measured in the scows; and

(2.) Soft mud, at 20 cents per cubic yard, as measured in the scows.

Work was commenced under this contract December 9, 1874, and was completed April 20, 1875, resulting in the dredging of 1,945 cubic yards of clay and bowlders, and 41,558 cubic yards of mud; altogether, 43,503 cubic yards, whereby the channel was completed to a width of 300 feet as originally projected.

From a recent examination of the condition of Long Point it appears that the portion of it for the protection and preservation of which a sea-wall and breakwater was projected and for which estimates have hitherto been submitted, no longer exists, having been washed away by storms, and that other works have been recently commenced by private parties upon that point, of such a character as to render unnecessary any further work on the part of the United States; so that no additional appropriation is now asked for the improvement of this harbor.

The following information in regard to the commerce and revenue of the port of Salem and Beverly for the year ending December 31, 1876, has been furnished by the United States collector of customs at that port:

The amount of revenue collected was:

Duties on imports	$17,161 51
Tonnage tax	501 00
Marine-hospital tax	258 27
Total	17,920 78
Value of imports	46,974 00
Value of exports	78,210 00

The number of vessels, both foreign and domestic, arriving and leaving the port during the same period was 1,221.

No vessels other than yachts were built in 1876.

A 12.

IMPROVEMENT OF BOSTON HARBOR, MASSACHUSETTS.

The works projected and commenced prior to 1866 for the improvement of Boston Harbor consisted of the sea-walls on Deer Island, Lovell's Island, and Great Brewster Island. Those on Deer Island were commenced in 1827, and were completed, as partially rebuilt in 1869; those on Lovell's Island were commenced in 1843, and completed in 1869, and that on Great Brewster Island was commenced in 1849 and completed in 1869.

On referring to the annual reports from 1866 to 1870, it appears that up to 1870 there had been expended upon the Great Brewster sea-wall the sum of $277,082.55, and for those upon Deer and Lovell's Islands the sum of $133,420.24, in addition to the appropriations made prior to 1866. These sea-walls, which had been under the charge of Col. H. W. Benham, Corps of Engineers, since 1865, were transferred to the charge of Lieut. Col. George Thom, Corps of Engineers, in April, 1873.

In 1866, new works for the further improvement of this harbor were planned by the Board of Harbor Commissioners, organized by the legislature of Massachusetts, and estimates therefor were submitted by them as follows, viz:

For the improvement of the channel across the Upper Middle Bar, by dredging a channel 23 feet deep at mean low-water and 1,000 feet wide, at a total estimated cost of	$157,085 00
For the improvement of the channel at the Narrows, by dredging off the southwest point of Lovell's Island and the extremity of Great Brewster Spit, so as to widen the channel to 685 feet, at 23 feet depth of water, at a total estimated cost of	188,805 00
For the improvement of the channel at the Narrows by the removal by blasting of Tower Rock and Corwin Rock, at an estimated cost of	20,000 00
For the preservation of the north head of Long Island, by the construction of a sea-wall, at an estimated cost of	150,000 00
For the preservation of the north end of Gallop's Island, by the construction of a sea-wall, at an estimated cost of	103,585 63
For the preservation of Point Allerton, by the construction of a sea-wall, at an estimated cost of	70,991 87
Total	690,467 50

An appropriation based upon these estimates having been made by Congress in March, 1867, the late Lieut. Col. John G. Foster, Corps of Engineers, was assigned to the charge of those works in May, 1867, and they continued under his charge until May, 1871, when they were transferred to Lieut. Col. George Thom, Corps of Engineers.

For the several works projected, as above, in 1866, the following appropriations have been made by Congress to date, viz:

By act of March 2, 1867, for preservation and improvement of Boston Harbor, Massachusetts	$375,000 00
Allotted under act of July 25, 1868	43,000 00
Allotted under act of April 10, 1869	82,170 00
By act of July 11, 1870, for preservation and improvement of Boston Harbor, Massachusetts	100,000 00
By act of March 3, 1871, for improvement of Boston Harbor, Massachusetts	100,000 00
By act of June 10, 1872, for the improvement of Boston Harbor, Massachusetts	100,000 00
By act of March 3, 1873, for the improvement of Boston Harbor, Massachusetts, including Deer and Lovell's Islands	150,000 00
By act of June 23, 1874, for continuing the improvement of the harbor at Boston, Massachusetts	100 000 00

By act of March 3, 1875, for the improvement of Boston Harbor, Massachusetts, $100,000, providing that of said amount $10,000 may be expended for the improvement of Hingham Harbor, Massachusetts.....	$90,000 00
By act of August 14, 1876, for the improvement of Boston Harbor, Massachusetts........	50,000 00
Total........	1,190,170 00

The following is a brief history of each of the works, completed and uncompleted, that have hitherto been projected for the improvement of this harbor, viz:

1.—SEA-WALL FOR THE PROTECTION AND PRESERVATION OF POINT ALLERTON.

Work was commenced upon this wall in September, 1870, and was completed in May, 1874. It was built for the most part under four separate contracts with Mr. James M. Andrews, of Biddeford, Me., made respectively May 24, 1870; July 26, 1871; August 24, 1872, and May 8, 1873. The total length of this sea-wall, completed, is 1,202 feet.

In addition to this sea-wall, there have been built since July, 1873, for the protection of its concrete foundation where most exposed to injury by storms and currents, 1,005 linear feet of granite apron and 8 jetties, in which have been placed 1,776 tons of grout. This apron has an average width of 10 feet and a height of 2 to 3 feet. It extends all along the fourth, fifth, sixth, seventh, and eighth faces, (counting from the east,) and for about 55 feet along the first face, as well as along the western wing-wall, in order to protect its junction with the shore-crest. The several jetties have a length of 25 to 30 feet, a width of about 6 to 8 feet, and a height of 2 to 3 feet; and they are placed, one at each of the fourth, fifth, sixth, seventh, and eighth angles, one each at the middle of the first and seventh faces, and at the easterly wing-wall.

This sea-wall is in excellent condition in every respect, and the riprap apron-work has fully answered the purpose for which it was intended.

2.—SEA-WALL FOR THE PROTECTION AND PRESERVATION OF GREAT BREWSTER ISLAND.

This wall, 2,840 feet in length, was built for the protection of the north and south heads of the island. It was commenced in the year 1849 and was continued through the year 1850, when work upon it was suspended. Since then it has been continued from time to time as appropriations have been made for it, until its completion in 1869. This wall is generally in good condition.

3.—SEA-WALLS FOR THE PROTECTION AND PRESERVATION OF LOVELL'S ISLAND.

Two sea-walls have been built by the United States Government on this island, one in 1843 for the protection of its north head for a length of 750 feet, and the other in 1868–'69 for the protection of its southeast bluff for a length of about 800 feet.

For the protection of the shore-line south of the north head-wall an apron-work of large rubble-stone was built in 1873 for a length of 620 feet, with 5 jetties projecting from it, in which 1,095 tons of stone were used; and for the protection of the shore-line next to the southern end of the southeastern sea-wall a rubble-stone apron 110 feet in

length was also built in 1873, in which 139 tons of stone were used. A recent inspection of these aprons shows that they have fully answered the purpose for which they were intended.

The wall on the southeast bluff was much damaged by storms last year, and especially by the gales of March and April, 1876. Over 500 linear feet of the coping-course has been loosened and more or less displaced, and more than 20 pieces have been thrown from the wall. Several stones of the facing-course next below the coping have also been loosened and displaced, and the cobble-stone paving back of the coping has been washed out for a length of about 400 feet. Injury has also been done to the stone jetties, and the joints in several places have been opened. To prevent a recurrence of such damage, it is recommended that greater relief be given to the wall (now but 8 feet above its concrete foundation) by adding two more facing-courses, each of 2 feet, and by substituting for the cobble-stone pavement in rear of the coping granite flagging resting on a shingle and gravel bed. The cost of this change, including the repairs now necessary, is estimated at $15,000.

4.—SEA-WALL FOR THE PROTECTION AND PRESERVATION OF GALLOP'S ISLAND.

This sea-wall is 1,785½ feet in length. Work upon it was commenced in 1868, under a contract with Mr. James Andrews, of Biddeford, Me., and was carried on under that contract until the end of April, 1871, after which it was continued with hired labor until its completion in the latter part of September, 1871.

The violent storms and currents to which this sea-wall is exposed had laid bare its concrete foundation to such a degree as to render necessary for its protection and preservation a rubble-stone apron for nearly its whole extent, with the addition of jetties in the most exposed places. This apron-work was commenced in August, 1873, and was completed in May, 1874. It extends along the sea-wall for a length of 1,655 feet, being on its most exposed faces 10 feet in width. Nine jetties have been built at and near the angles of the wall, four of which are of split granite, bedded in part in concrete laid in trenches and surrounded with a concrete apron, each jetty being 18 feet in length and 5 feet in width. The quantity of stone used in this apron and the jetties was about 1,450 tons. A recent inspection of this work shows that it is in good condition, and that the riprap apron work and jetties have fully answered the purpose intended.

5.—SEA-WALL FOR THE PROTECTION AND PRESERVATION OF THE NORTH HEAD OF LONG ISLAND.

Work was commenced upon this sea-wall in August, 1870, and was completed in July, 1874. It has been built for the most part under four separate contracts with Mr. James Andrews, of Biddeford, Me., made respectively May 24, 1870; July 26, 1871; August 23, 1872, and May 8, 1873. The length of this sea-wall is 2,081¾ feet.

In addition to the sea-wall, there has been built for the protection and preservation of its concrete foundation, where most exposed to injury by storms and currents, a rubble-stone apron for a length of 975 feet in front of the wall, together with 10 stone jetties. This apron averages from 8 to 10 feet in width and from 2 to 3 feet in height. The jetties are triangular in shape, and project from 12 to 20 feet beyond the apron; about 900 tons of rubble-stone was used for this work, together with a large quantity of bowlders and cobble-stone, found in its immediate vi-

cinity. This apron-work was commenced in April, 1874, and completed early in August, 1874.

A recent inspection of this sea-wall shows that it is in good condition, and that the riprap apron-work and jetties have fully answered the purpose intended.

6.—SEA-WALLS FOR THE PROTECTION AND PRESERVATION OF DEER ISLAND.

Under appropriations made by Congress in 1827, and subsequently, three sea-walls have been built for protecting the three prominent heads of this island: that at the north head being 1,740 feet long, and 19½ feet high above its foundation, and 14 feet above ordinary high-water; that at the middle head 840 feet long, 17½ feet high above its foundation, and 12 feet above mean high-water; and that at the south head 380 feet long, 14½ feet high above its foundation, and 12 feet above mean high-water. These walls were built of regularly split quarried stone, with a partial dressing only, and laid dry as headers, the only backing being the clay and gravel in rear, which, silting out through the open joints, left, in course of time, large cavities at several places in rear of the walls, resulting in much damage to the walls, with a probability of their entire destruction. To repair the damage already done, and to prevent its recurrence for the future, the rebuilding of these walls was commenced in 1865, by which its several courses, except the lowest, were laid in mortar and backed with concrete, and otherwise much strengthened. This rebuilding was continued until the latter part of 1869, with the following result, as reported by Col. H. W. Benham while in charge of these walls:

The rebuilding of the wall of the middle head was completed in 1867 for an extent of 540 feet; all that then appeared to be necessary.

The wall of the South Head was commenced and completely rebuilt in a substantial manner, comprising about 420 running feet, in the year 1867.

The rebuilding of the wall at the North Head was continued until August, 1869, up to which time 1,250 linear feet of wall was taken up, relaid, and completed in rear, two split-stone jetties, 25 to 28 feet long, were placed, one at about the middle of the main face of the North Head, and the other in a similar position at the Middle Head wall.

In his report for the fiscal year ending June 30, 1872, Colonel Benham states that the three sea-walls pertaining to these bluffs of Deer Island were "in essentially a good condition, especially in the parts that had been rebuilt; that a few defects are found by the falling or drawing out of the foundation-stones, even, in some cases, of the parts rebuilt, from their not having been taken up to the lowest foundation-course, and from the great force of the current or waves along these foundations."

In the latter part of 1876 some repairs were made on the wall at the North Head, and an inspection recently made shows that no additional repairs are needed for the present.

7.—STRAIGHTENING, WIDENING, AND DEEPENING THE MAIN SHIP-CHANNEL AT THE WEST END OF GREAT BREWSTER SPIT.

This work consisted in the removal by dredging of the southern portion of this spit so far as to obtain a depth of 23 feet at mean low-water for a width of not less than 600 feet with proper slopes up to the 18-feet curve. A survey of this locality, made in August, 1872, showed that the extreme westerly end of the spit had so far advanced into the chan-

nel that the low-water line was 120 feet further out than it was in 1860, and the 18-feet curve was 168 feet from that of 1860.

Under the appropriation made by act of June 23, 1874, for the improvement of this harbor, a contract was made September 3, 1874, with the New England Dredging Company, of Boston, Mass., the lowest responsible bidders, for completing this work. Work was commenced under this contract on the 13th of October, and continued until the 29th of October, 1874, when it was suspended for the winter. It was resumed on the 11th of May, 1875, the earliest date practicable, and was continued up to the middle of August, 1875, when all the dredging called for under this contract was completed, resulting in 29,226 cubic yards. Under the same contract with the New England Dredging Company, 95½ cubic yards of sunken ledge (laid bare by dredging) were removed to the depth of 23 feet at mean low-water. This work was commenced in June, 1876, and completed in November, 1876.

8.—STRAIGHTENING, WIDENING, AND DEEPENING THE MAIN SHIP-CHANNEL AT THE SOUTHEAST AND SOUTHWEST POINTS OF LOVELL'S ISLAND.

This work consists in the removal by dredging of the southeast and southwest points of this island, so as to give in "The Narrows" a channel 600 feet in width for a depth of 23 feet at mean low-water, with proper slopes up to the 18-feet curves. Work was commenced on the southwest point in 1867, under a contract made with Mr. A. Boschké, of Boston, Mass., and was continued during that and the two following seasons, until suspended for want of funds. A resurvey of this channel made in 1872, showed that it had not changed to any considerable extent at its southwest point since the close of the dredging operations in 1869; that the 18-feet curve was very nearly the same as then, and that the shore above low-water line had acquired a more natural slope of 8 feet horizontal to 1 foot rise by the receding inland of the high-water line, but that the flats off the *southeast* point of this island had advanced so much toward the main channel as to materially impede and endanger navigation.

Under the appropriation made by act of June 23, 1874, for the improvement of Boston Harbor, a contract was made September 8, 1874, with Messrs. Boynton Brothers, of Boston, Mass., the lowest responsible bidders, for completing the work projected for the improvement at the southeast point of this island, viz, 40,000 cubic yards, more or less, of dredging, at 38 cents per cubic yard, as measured in the scows. Work under this contract was commenced on the 7th of October, and continued until the 17th of December, 1874, when it was suspended for the winter. It was resumed on the 11th of May, 1875, the earliest date practicable, and was completed September 22, 1875, 31,058 cubic yards having been dredged under this contract.

For completing the projected improvement at the southwest point of this island, about 40,000 cubic yards of additional dredging will be necessary, for which a contract was made June 2, 1877, with the New England Dredging Company, of Boston, Mass., the lowest of eight bidders, at 24 cents per cubic yard, as measured in the scows. Operations were commenced under this contract on the 19th of June, and it is probable that they will be completed not later than the 1st of November, 1877, as required by the contract.

9.—STRAIGHTENING, WIDENING, AND DEEPENING THE MAIN SHIP-CHANNEL AT THE UPPER MIDDLE BAR.

The work projected for the improvement of this bar consists in opening through it a channel, 600 feet in width, to a depth of 23 feet at mean low-water, through a total distance of about 4,000 feet. the principal difficulties being in a space about 2,200 feet in length, in which the depth to be increased varied from 1 to 7 feet. Under a contract made September 24, 1870, with Emory R. Seward, of Albany, N. Y., dredging was carried on at this place until the 1st of June, 1871, at which time 26,120 cubic yards had been excavated under that contract, by which one cut, about 1,800 feet in length, was partially opened to a width of 40 feet, and to a depth varying from 20 to 23 feet at mean low-water.

Under the appropriation made by act of March 3, 1871, a new contract was made July 29, 1871, with Mr. R. G. Packard, of Brooklyn, N. Y., which was completed June 29, 1872, by 20,305 cubic yards of dredging, making, to that date, an aggregate of 46,425 cubic yards of dredging. By this work, one cut, about 1,800 feet in length, was opened to a width of 40 feet, to a full depth of 23 feet at mean low-water, and a second cut of the same width and depth for a length of 1,040 feet, including the removal of a very large bowlder discovered in 1872, in the main ship-channel, with but 16½ feet of water upon it at mean low-water.

Under the appropriation of March 3, 1873, a contract was made March 5, 1874, with the Atlantic Dredging Company, of Brooklyn, N. Y., for 75,000 cubic yards, more or less, of dredging, at 64 cents per cubic yard, as measured in the scows, and at $35 per cubic yard for excavation of ledge and of bowlders exceeding 6 tons in weight. Operations were commenced in April, 1874, and were continued up to the 14th of December of that year, when they were suspended for the winter. On the 26th of May, 1875, they were resumed, and continued up to the 17th of December of that year. They were again resumed on the 3d of May, 1876, and were continued up to the 11th of July, 1876, at which time 90,860 cubic yards had been dredged under and in completion of this contract.

Under the appropriation made by act of June 23, 1874, for continuing the improvement of this harbor, a contract was made September 1, 1874, with the Harbor Improvement Company, of Boston, Mass., for 42,000 cubic yards of additional dredging on this bar, at 85 cents per cubic yard, as measured in the scows. Dredging was commenced under this contract on the 3d of October, and continued until the 14th of December, 1874, when it was suspended for the winter. It was resumed on the 8th of May, 1875, and continued up to the 17th of December, 1875, at which time 42,843½ cubic yards had been dredged under this contract. There then remained to be done for the completion of this contract, the excavation of 37 cubic yards of ledge, which was completed on the 26th of August, 1876.

Under the appropriation made for this harbor by act of March 3, 1875, a contract was made May 19, 1875, with Messrs. Curtis, Fobes & Co., of Portland, Me., for 90,000 cubic yards, more or less, of additional dredging on this bar and the shoals below it, at 75 cents per cubic yard, as measured in the scows, including bowlders not exceeding 6 tons in weight. Operations were commenced under this contract May 9, 1876, and were completed on the 16th of November, 1876, resulting in 88,150 cubic yards of dredging.

The total quantity of dredging, therefore, that has been done up to date under the several contracts named, amounts to 266,794 cubic yards, whereby a channel has been opened for a width of 600 feet, and a depth

of 23 feet at mean low-water, through the whole of the Upper Middle Bar, in length about 4,000 feet.

In order to complete the projected channel at the Upper Middle Bar, there still remains to be done about 80 cubic yards of rock excavation, for which a contract was made June 4, 1877, with Mr. George W. Townsend, of Boston, Mass., the lowest of two bidders, at $65 per cubic yard measured in its bed, the same to be completed on or before the 30th of June, 1878.

10—REMOVAL OF NASH'S ROCK (SHOAL.)

Nash's Rock, so-called, is a shoal lying in the outer entrance to Boston Harbor, about one-third of the way over from Brewster Spit to Point Allerton. This shoal was surveyed in September and October, 1873, and a special report thereon, accompanied by drawings, was submitted to the Department on the 24th of March, 1874. From information acquired by this survey, it is seen that the only portion of this shoal which it would be advisable and practicable to improve, is that having less than 21 feet of water over it at mean low-water, which portion has an area of 637½ superficial yards, and would require, in order to obtain a depth of 21 feet, the excavation and removal of about 500 cubic yards of bowlders, shingle, &c., at an estimated cost of $10,000; whereas to remove the whole shoal to a depth of 23 feet below the plane of mean low-water would require the excavation of over 16,000 cubic yards of similar material over an area of $9\frac{1}{16}$ acres, the cost of which would be greatly disproportionate to the benefit that would result therefrom.

Under the appropriation made by act of March 3, 1875, for the improvement of this harbor, a contract was made May 19, 1875, with Messrs. Curtis, Fobes & Co., of Portland, Me., for removing about one half of this shoal to the projected depth of 21 feet at mean low-water, which was completed by them in September, 1876.

Arrangements have been made for the entire completion of this work during the present season by employing a submarine party, with a vessel and crew, by the day, at a price not exceeding $50 per day.

11.—REMOVAL OF KELLY'S ROCK.

This rock lies in the main ship-channel, distant about 700 yards, in a direction southeast by south of Bug light (at the Narrows) and in the line of entrance to buoy No. 1 and Bug light. In 1869 operations were commenced for removing this ledge to a depth of 23 feet below the plane of mean low-water, and were continued up to the end of December, 1870. These operations were continued in June and July, 1873. An accurate survey, since made, of this rock showed that there still remained an area of about 320 superficial yards of this ledge which had less than the projected depth on the shoalest parts, of which there were but 21.2 feet of water at mean low-water, and that in order to obtain the full depth of 23 feet would require the removal of not less than 80 cubic yards of the ledge.

Under the appropriation made by act of March 3, 1875, for this harbor, a contract was made May 14, 1875, with Mr. George W. Townsend, of Boston, Mass., for completing the removal of this rock at $60 per cubic yard. He commenced operations under this contract in the latter part of May, and completed in September 30, 1875.

During the removal of this rock in 1875, new ledges were discovered in its vicinity, above and below, having on the shoalest parts a depth of but 20 to 21 feet at mean low-water. These ledges cover an area of

about 543 square yards in the 23 feet plane below mean low-water, and 189 cubic yards will have to be removed above that plane.

A contract for the removal of these ledges to a depth of 23 feet at mean low-water was made on the 4th of June, 1877, with Mr. George W. Townsend, of Boston, Mass., the lowest of two bidders, at $50 per cubic yard, measured in its bed, the same to be completed on or before the 30th of June, 1878. Operations were commenced under this contract on the 15th of June, 1877.

12.—REMOVAL OF TOWER ROCK.

This rock was situated in the main ship-channel at the Narrows, about 100 yards to the southwest of Great Brewster Spit light. It was blasted out and removed in 1867 to the projected depth of 23 feet at mean low-water.

13.—REMOVAL OF CORWIN ROCK.

This rock was situated in the main ship-channel at the narrows, about 200 yards to the southwest of Great Brewster Spit light. It was blasted out and removed in the years 1868 and 1869 to the projected depth of 23 feet at mean low-water.

14.—REMOVAL OF SUNKEN LEDGE BETWEEN GEORGE'S ISLAND AND GREAT BREWSTER SPIT.

This ledge was discovered in September, 1872, in a resurvey of the Narrows. It was situated near the middle of the main ship channel, directly in the track of all large vessels, and particularly of the European steamers, and was distant 317 yards in a direction west by south from Bug light. It had but 18.9 feet of water upon it at mean low-water, and was therefore a dangerous obstacle to navigation.

Under the appropriation of June 23, 1874, a contract was made, August 31, 1874, with Mr. William H. Lloyd, of Boston, Mass., for the removal of this ledge to a depth of 23 feet at mean low-water—altogether 16⅛ cubic yards—for the sum of $400, which he completed early in September, 1875.

15.—REMOVAL OF BARREL ROCK, IN BROAD SOUND.

This was a bowlder lying about 1 mile a little north of west from Green Island, and near the sailing-line of the Portland and other Maine steamers. It had only 4 feet of water over it at low tide, and in thick weather was a dangerous obstacle to navigation. It was removed in 1869.

16.—REMOVAL OF STATE AND PALMYRA ROCKS.

A special survey was made of these rocks, of which a report and drawings were transmitted to the Department on the 25th of May, 1874. By this survey it was ascertained that State Rock and Palmyra Rock, of the position and character of which but little previously had been known, are situated very near each other, and most probably are outcroppings of the same ledge, forming spurs on the southern side of the lower middle bar, about one-half a mile east of Castle Island.

To effect the improvement proposed, required altogether the removal of about 62 cubic yards of rock, for which a contract was made August 31, 1874, with Mr. William H. Lloyd, of Boston, who was the lowest of two bidders, at $1,500 for the job. Mr. Lloyd commenced work upon the removal of the rocks in September, 1874, and continued up to the middle of November, when, on account of the weather, he was obliged to suspend for the winter. He resumed work about the 1st of June, 1875, and completed their removal on the 15th of that month.

17.—REMOVAL OF THE WRECK OF THE SCHOONER DELOS.

This was an old vessel of about 100 tons burden deeply loaded with gravel in her hold and on deck, destined for the engineer-work at Fort Warren, and was sunk in the gale of November 12, 1872, in Nantasket Roads, about 100 yards from Fort Warren wharf, in about 22 feet of water at low-water. When examined in December, 1872, she was stripped of her masts and rigging, and was much shattered, and had about 14 feet of water over her at mean low-water. The breaking up and removal of this wreck was commenced on May 29, 1873, and was completed in the early part of June.

From the foregoing statement it is seen that nearly all the works hitherto projected for the improvement of Boston Harbor have been completed, and that those remaining to be completed are:

1. About 40,000 cubic yards of dredging at and near the southwest point of Lovell's Island, in order to obtain the contemplated width and depth of channel.
2. Eighty-one and one-half cubic yards of rock-excavation at the Upper Middle Bar, for completing the channel to the projected width of 600 feet and a depth of 23 feet at mean low water.
3. Removal of Nash's Rock, (shoal.)
4. The removal of about 189 cubic yards of sunken ledge, discovered in 1875 in the vicinity of Kelly's Rock, for which a contract was made June 4, 1877, to be completed on or before June 30, 1878.
5. Removal by dredging of Man-of-War Shoal, as per project submitted in special report dated December 16, 1876, a copy of which is hereto appended.

In addition to the above, the southeastern sea-wall on Lovell's Island will require raising and repairing, for which no funds are now available.

In the appropriation for this harbor, made by act of Congress approved March 3, 1875, provision was made for the improvement of Hingham Harbor, Massachusetts, to an extent not exceeding $10,000. A careful survey of this harbor, made in October and November, 1874, showed the nature and extent of the improvements required for the commerce of that place, the project for which consisted in widening and deepening the channel so as to have a width of not less than 100 feet and a depth of 8 feet at mean low-water, or about 6 feet at low-water in spring-tides. For this improvement the following work has been done, viz, 25,160 cubic yards of dredging and 80 cubic yards of ledge-excavation. Proposals were invited for this work, and contracts therefor were made, as follows, viz:

1. With Messrs. Curtis, Fobes & Co., of Portland, Me., May 19, 1875, for the dredging, at 18 cents per cubic yard, which they completed on the 1st of May, 1876.
2. With Mr. George W. Townsend, of Boston, Mass., for 67 cubic yards ledge-excavation, at $39 per cubic yard, which he completed in December, 1875.

In addition to the above, about 12 cubic yards of sunken ledge, subsequently discovered, had been removed, whereby all the work projected for the improvement of Hingham Harbor has been completed, at a total cost (including contingencies) of $9,116.58.

The following is an estimate of the cost of completing the several works yet remaining to be done (as above) for the improvement of Boston Harbor, viz:

1. Forty thousand cubic yards dredging at the southwest point of Lovell's Island, contracted for at 24 cents per cubic yard	$9,600 00
2. Completing the channel through the Upper Middle Bar, by the removal of 81½ cubic yards of sunken ledge, contracted for at $65 per cubic yard, as measured in its bed	5,297 50
3. Removal of Nash's Rock, (shoal)	5,000 00
4. Removal of 189 cubic yards of sunken ledge near Kelly's Rock, contracted for at $50 per cubic yard	9,450 00
5. Raising and repairing sea-wall on Lovell's Island, (new estimate)	15,000 00
6. Removal of Man-of-War Shoal, as per new estimate, 65,000 cubic yards of dredging, at 60 cents per cubic yard	39,000 00
Add for engineering expenses and other contingencies, say	12,944 11
Total	96,291 61
Amount available July 1, 1877	41,291 61
Additional amount required for completing all the work now projected for the improvement of Boston Harbor	55,000 00

On comparing the original estimate of the cost of the several works proposed to be done in 1866, as then submitted, with the actual cost of the same as now finished, it will be seen that the actual cost has been about 50 per cent. higher than the original estimate, which excess is probably owing to the want of exact data upon which to base that estimate, as well as the price of material and labor having been assumed too low; and for other completed works no detailed estimates appear to have been submitted; while for a greater part of the works since projected from time to time those completed have generally cost about the same as estimated.

The several works built for the improvement of this harbor lie within the port of Boston, and in the collection-district of Boston and Charlestown, Massachusetts.

The following information in regard to the revenue and commerce of the port of Boston for the year ending December 31, 1876, has been furnished by the United States collector of customs at that port, viz:

Amount of revenue collected: coin, $12,788,559.58; currency, 198,036.59.	$12,986,596 17
Value of imports	35,362,993 00
Value of exports: domestic merchandise, $43,012,403; foreign merchandise, $1,344,441	44,356,844 00

	Number.	Tonnage.
American vessels arrived	644	248,339
Foreign vessels arrived	1,281	442,027
American vessels cleared	525	213,773
Foreign vessels cleared	1,242	427,700
Coastwise arrivals	1,018	1,042,501
Coastwise clearances	1,437	1,187,188

Number of vessels built, 32, with an aggregate tonnage of 11,596 $\frac{48}{100}$.

The following-named papers are hereto appended, viz:

1. Report on survey of Man-of-War Shoal, dated December 16, 1876.
2. Abstract of proposals received.
3. Abstract of contracts made.

Money statement.

July 1, 1876, amount available	$80,455 29	
Amount appropriated by act approved August 14, 1876	50,000 00	
		$130,455 29
July 1, 1877, amount expended during fiscal year	87,917 46	
July 1, 1877, outstanding liabilities	246 12	
		88,163 58
July 1, 1877, amount available		42,291 71
Amount (estimated) required for completion of existing project		55,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		55,000 00

SURVEY OF MAN-OF-WAR SHOAL, IN BOSTON HARBOR, MASSACHUSETTS.

UNITED STATES ENGINEER OFFICE,
Portland, Maine, December 16, 1876.

GENERAL: I have the honor to submit the following report on the survey of Man-of-War Shoal, in Boston Harbor, Massachusetts.

This shoal lies off the northeast point of the city of Boston, at the confluence of Charles and Mystic Rivers, in the upper harbor, and in the track of vessels approaching Charlestown navy-yard. A survey and map of this shoal was made in 1874, under the direction of the Massachusetts board of harbor commissioners, with a view to its improvement, of which the accompanying drawing is a copy.

Between this shoal and the wharves of Boston the area shaded in black on the drawing has been dredged to a depth of 23 feet at mean low-water, under the direction of the said board of harbor commissioners, leaving still to be removed the present shoal, which has an area of about 10 acres in the plane 23 feet below mean low-water, with about $15\frac{1}{4}$ feet of water over its shoalest part at mean low-water, the mean rise and fall of the tide being $9\frac{8}{10}$ feet.

The quantity of material that will have to be excavated to give a depth of 23 feet at mean low-water is 50,860 cubic yards measured *in situ*, or say about 65,000 cubic yards measured in dredging-scows.

Numerous borings, recently made at this shoal under my direction, show that the material of which it consists varies in character from soft yellow clay to blue clay and hard-pan; and that it is covered in most parts with a sandy matter and gravel and some shells from a depth of a few inches to 5 feet; and that the western part of the shoal appears to be formed chiefly of sandy matter and gravel, and the eastern part of yellow clay and hard-pan.

This shoal has existed from time immemorial, and, as stated by the harbor commissioners—

> Has always been an obstacle to the maneuvering of the heavy ships of the Navy in their passage to and from the United States navy-yard, which is above it, and the difficulties arising from its existence are becoming more and more serious in their effect upon the commerce of the port, from the fact that the larger and deeper vessels of modern times require a greater depth of water than can now be carried over this shoal.

The estimated cost of the removal of this shoal by dredging to a depth of 23 feet at mean low-water is as follows, viz:

Sixty-five thousand cubic yards of dredging, including a carriage of material for a distance of 5 miles at 60 cents per cubic yard as measured in the scows....	$39,000 00
Adding for engineering expenses and other contingencies..................	4,000 00
Total..	43,000 00

Respectfully submitted,

GEO. THOM,
Lieut. Col. of Engineers, Bvt. Brig. Gen. U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

Abstract of proposals received May 26, 1877, for improvement of Boston Harbor, Massachusetts.

Number for reference.	Bidders.	Residence.	Dredging at and near southwest point of Lovell's Island, as measured in the scows.	Ledge Upper Middle Bar, as measured in its bed.	Ledges near Kelly's Rock, as measured in its bed.
			Per cu. yd	Per cu. yd.	Per cu. yd.
1	New England Dredging Company	Boston, Mass	$0 24		
2	George Whiting	Boston, Mass	27		
3	Atlantic Dredging Company	Brooklyn, N. Y	27		
4	Elijah Brainard, jr	Albany, N. Y	32		
5	Sidney F. Shelbourne	New London, Conn	34		
6	George C. Fobes & Co	Portland, Me	36		
7	W. S. Fretch & Co	Boston, Mass	37½		
8	Augustus R. Wright	Portland, Me	40		
9	George W. Townsend	Boston, Mass		$65 00	$50 00
10	Gardner Floyd	Portland, Me		67 00	62 50

Abstract of contracts made during the fiscal year ending June 30, 1877, for the improvement of Boston Harbor, Massachusetts.

Date of contract.	Contractors.	Nature and location of work.	Price per cubic yard.	Remarks.
1877.				
June 2	New England Dredging Company, Boston, Mass.	Dredging at and near southwest point of Lovell's Island, including that on Cape Cod Shoal opposite Lovell's Island.	$0 24	As measured in the scows.
June 4	George W. Townsend, Boston, Mass.	Removal of sunken ledge at Upper Middle Bar.	65 00	As measured in its bed.
		Removal of sunken ledges near Kelly's Rock.	50 00	Do.

A 13.

IMPROVEMENT OF PLYMOUTH HARBOR, MASSACHUSETTS.

The existence of this harbor depends entirely upon the protection and preservation of Long Beach, which is a narrow strip of land that extends 2¾ miles out from the main land in a northwesterly direction, nearly parallel to the shore of the town of Plymouth, and distant from it about 1 mile. It affords to the harbor its only shelter from easterly storms. In late years it has been washed away in some places, and much weakened in others, to an extent seriously threatening the ruin of the harbor. For the protection and preservation of this beach, various works have been built from time to time, until finally they have proved efficient and successful.

The total amount that has been appropriated by Congress for the preservation and improvement of this harbor, from 1824 up to and including 1875, as shown by statement furnished under date of February

1, 1876, by the Chief of Engineers for the information of the Committee on Commerce of the House of Representatives, is $97,766.

Of this amount there has been allotted to and appropriated for this harbor, since the resumption of works on rivers and harbors in 1866, the sums as follows, viz:

Amount allotted in 1866 from appropriations made for harbors on the Atlantic coast	$8,300 00
Amount allotted under act of July 25, 1868	7,500 00
Appropriated by act approved July 11, 1870	10,000 00
Appropriated by act approved March 3, 1871	10,000 00
Appropriated by act approved June 10, 1872	2,500 00
Appropriated by act approved March 3, 1873	3,000 00
Appropriated by act approved June 23, 1874	5,000 00
Appropriated by act approved March 3, 1875	10,000 00
Total	56,300 00

In 1866, under the allotment of $8,300 for Plymouth Harbor, a wooden breakwater was built by contract for the protection of Long Beach, under charge of Maj. Jared A. Smith, Corps of Engineers. In the annual report for the fiscal year ending June 30, 1867, it is stated that—

> One thousand three hundred linear feet of that breakwater had been built. It consists of triangular frames placed at intervals of 4 feet, covered with 2-inch plank, set in a trench 12 feet wide and 3 feet deep, the trench and frame being filled to the level of the ground. It is situated on the crest of a ridge of sand, of about 3 miles in extent, and of an average width of 800 feet. At intervals along this ridge there are depressions, through which the sea breaks with great violence. It is in these intervals that the breakwater is placed.

In 1867 other work was added by the State of Massachusetts, at an expense of about $2,000.

> These works were then deemed sufficient to resist any action of the sea, but a storm in the autumn of 1867 carried away some of the more exposed portions, and a second, occurring the subsequent winter, when tides were highest, carried away about 1,000 linear feet of the strongest portion of the work, besides doing other damage, leaving the northern portion of the beach, adjacent to the main entrance of the harbor, entirely unprotected from the open sea, save by some remaining portions of a work completed in 1832, and the beach itself so much reduced as to be entirely submerged, at extreme high tides, for a length of 1,500 feet. The sand was such that while a slight action of the sea would raise the beach, the prevailing winds and heavier seas would drive the sand into the channel, and it was evident that a severe storm would not only seriously injure the beach thus unprotected, but also the main channel, and leave it entirely exposed to further encroachments.

Under an additional allotment of $7,500, made in August, 1868, out of the appropriation of July 25, 1868, 200 linear feet of substantial crib-work of timber, covered with plank, and 175 linear feet of triangular work (similar to that built in 1866) were built by contract in the autumn of 1868, for the further protection of Long Beach, where injured by storms of the previous autumn, Major Smith having been in charge of the work.

Under the appropriation of $10,000, made by act of July 11, 1870, a contract was made by the late Lieut. Col. J. G. Foster, Corps of Engineers, then in charge of the work for the construction near the outer end of Long Beach of about 1,700 linear feet of bulkhead and jetties, built of frame-work and filled with brush and ballasted with stone. This work was commenced September, 1870, and completed before the close of that season.

In May, 1871, the charge of Plymouth Harbor improvement was transferred to Lieut. Col. George Thom, Corps of Engineers, by whom contracts were made under the appropriation of March 3, 1871, for completing the projected bulkhead and jetties on the extremity of Long

Beach, at \$3.86 per linear foot, and for furnishing and placing granite grout upon the stone bulkhead, to connect the outer end of the beach with the beacon, at \$2.25 per ton. Work was commenced under both contracts in June, 1871; that on the brush bulkhead and jetties was finished in August, 1871, 641½ linear feet having been built under the contract, and the contract for the stone was completed in September, 1871, 2,028 tons having been furnished. The balance of the appropriation of 1871 was applied to the repairs of the bulkhead and jetties previously built upon Long Beach, in places where they had been damaged by storms, and to the planting of beach-grass on the beach, where most necessary for its preservation.

Under the appropriation of June 10, 1872, (\$2,500,) the following repairs were made in July and August of that year, viz:

1. In making about 200 linear feet of brush bulkhead and jetties, to replace that damaged by the storm in November, 1871;

2. In strengthening the outer part of the bulkhead with 613 tons of stone, purchased for that purpose;

3. In making 300 linear feet of single brush jetties, and 250 linear feet of small stone jetties; and

4. In planting 10,800 hills of beach-grass.

This work was done by hired labor, and with materials purchased in open market, as authorized so to do.

The appropriation of \$3,000, made by act of March 3, 1873, was applied to continued repairs upon all the works previously built; to the building of stone and brush groins outside and inside the bulkhead at the outer end of Long Beach, and to planting over 10,000 hills of beach-grass on the newly-formed beach and in other places where most necessary.

The appropriation of \$5,000, made by act of June 23, 1874, was applied to the completion of all the stone and brush groins on the outer end of Long Beach; to increasing in height and strength the stone bulkhead connecting the beacon with the outer end of the beach; to building a small bulkhead of frame-work, brush, and stone, 290 feet in length, for protecting the beach about 1 mile from its inner end; to planting beach-grass and making repairs where most necessary for the protection and preservation of Long Beach. This work was done by hired labor and with materials purchased in open market, and was completed in August, 1875.

From the foregoing it is seen that the several amounts that have been allotted to and appropriated for the improvement of Plymouth Harbor since 1866 have been applied to the construction of bulkheads, jetties, and groins, and the planting of beach-grass where most necessary for protecting and strengthening Long Beach throughout its whole extent of about 2¾ miles.

These bulkheads consist of triangular frames, (built in 1866 and 1868,) or of crib-work of timber covered with plank, (built in 1868,) and those built in 1870 and 1871 of a frame-work well secured in the ground, filled with brush and ballasted with stone, that connecting the outer end of the beach with the beacon being built entirely of rubble-stone.

The jetties consist of a frame-work filled with brush and ballasted with stone, and the groins of small stones intermixed with brush, and sometimes of brush alone. These groins, 33 in number, are built out perpendicularly from the main bulkhead on the seaward side, varying in length from 75 to 265 feet, and aggregating 5,250 feet in length, and from 50 to 150 feet apart. Others have been built inside the bulkhead in places where most necessary. They were made by placing brush

upon the surface of the beach and piling upon it beach-bowlders to a height of about 2 feet and for a width of 5 feet. The brush-groins were made by digging a trench 2 feet by 2 feet, and placing brush in it upright and as close as practicable, the brush being held by sand being thrown into the trench and well rammed down, and sometimes further protected by small bowlders placed in a row along the sides of the groin. The brush rises about 2 or 3 feet above the surface of the beach.

The bulkheads and jetties had already accumulated a large quantity of sand, forming a ridge throughout its whole extent, but with a view to increasing its strength and efficiency, the several groins have been built, and have fully answered the purpose for which they were intended. Beach-grass has been planted, and covers nearly all this newly-formed beach, which is now in an efficient condition. Repairs will, however, continue to be necessary from time to time, as they now are, along this beach, exposed as it is to injury by violent storms. Something more should also be done for increasing the efficiency of the stone bulkhead at the outer end, and its connection with the beach, the estimated cost of which is as follows, viz:

1. 1,000 tons rubble-stone, at $2	$2,000 00
2. Repairs of bulkhead near inner end of beach, (partially burned of late)	250 00
3. Repairs of bulkhead and jetties	750 00
Adding for contingencies, say	500 00
Total	3,500 00

A survey was made of this harbor in February, 1874, under my direction, in compliance with a resolution of the House of Representatives dated December 10, 1873, "with a view to dredging and improving the same, so as to afford greater protection and facilities to commerce."

To make this portion of the harbor practicable for "beating up" with sailing-vessels would require a width of not less than 500 feet, which would necessitate the excavation of about 80,000 cubic yards of hard sand on the Middle Ground and Spiltting Knife Bars, which obstruct the present channel, and about 320,000 cubic yards of mud and clay between the Middle Ground and Long Wharf, at a probable cost of not less than $176,000, and with a likelihood that the improvement would be but temporary, as the same causes which have already produced the existing shoals would, it is more than probable, reproduce them. Should it be decided to improve this harbor by dredging, it is recommended that it should be applied to the opening of a channel 100 feet in width and 6 feet in depth at mean low-water, from the end of Long Wharf outward in continuation of the present main channel above the Middle Ground. A channel of this width would enable vessels to be towed up to the vicinity of the wharves of the town, and would probably be kept open by the scour of the ebb-tide deflected into it from Town Brook.

The estimated cost of this channel was as follows, viz:

Sixty-four thousand cubic yards, at 40 cents per cubic yard	$25,600 00
Add for contingencies, say	2,400 00
Total	28,000 00

Under the appropriation of $10,000, made by act of March 3, 1875, for improving this channel as above projected, a contract was made May 13, 1875, with Mr. Augustus R. Wright, of Geneva, N. Y., the lowest bidder, at 23 cents per cubic yard, as measured in the scows, for 35,000 cubic yards, more or less, of dredging, to be applied to the partial excavation of the projected channel. Dredging was commenced under this contract

on the 19th of April, 1876, and was completed on the 21st of June, 1876, resulting in 34,985 cubic yards of dredging, whereby a channel was opened up to the wharves of Plymouth for a width of 50 feet, and to a depth of 6 feet at mean low-water.

After further considering the wants of commerce and the facilities required, it is recommended that a basin be excavated at the upper end of the channel in front of the wharves where vessels may lie secure and be able to pass each other at any stage of the tide. Here it now averages 1 foot bare at mean low-water, and it is recommended that the basin be excavated to a depth of 8 feet at mean low-water, for an area of 12,500 square yards, which would require about 45,000 cubic yards of dredging in addition to that called for in the estimate submitted in February, 1874. With this modification in the project, the following estimate is submitted for completing the improvement of this harbor, viz:

1. 30,000 cubic yards of dredging for completing channel as per original estimate, at 30 cents per cubic yard	$9,000 00
2. 45,000 cubic yards additional for basin, at 30 cents per cubic yard	13,500 00
3. For continuing the works for the protection and preservation of Long Beach	3,500 00
Adding for contingencies, say	4,000 00
Total	30,000 00

The amount of revenue, commerce, and navigation for this port is shown in the accompanying letter of the United States collector of customs.

Money statement.

July 1, 1876, amount available	$327 42
July 1, 1877, amount expended during fiscal year	233 50
July 1, 1877, amount available	93 92
Amount (estimated) required for completion of existing project	30,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	30,000 00

COMMERCIAL STATISTICS.

CUSTOM-HOUSE, PLYMOUTH, MASS.,
Collector's Office, July 10, 1877.

SIR: I have the honor to acknowledge the receipt of your letter of the 11th ultimo, and in answer beg leave to inform you that during the year ending December 31, 1876, the amount of revenue collected at the port of Plymouth was $16,478.83.

Amount of domestic merchandise exported to foreign ports		$14,750 00
And during the same period the entrances and clearances, foreign, were		6 vessels.

The number of arrivals, coastwise, at this port consisted of—

47 cargoes of coal, amounting to	10,152 tons.
23 cargoes of iron, amounting to	2,103 tons.
1 cargo of sand, amounting to	175 tons.
16 cargoes of lumber, amounting to	2,225,000 feet.
13 cargoes of salt, amounting to	560,900 pounds

22 vessels from the Grand Bank fisheries with	14,342 quintals codfish, value	$71,710 00
	4,441 gallons fish-oil, value	2,665 00
7 vessels from the Bay fisheries with 4,980 barrels mackerel, value		39,470 00
4 vessels from the lobster-fisheries with 129,000 lobsters, value		7,740 00
Total value of fisheries		121,585 00

Besides the above, there were sundry cargoes of nails, hollow ware, hoops, staves, barrels, hay, and other commodities to and from Plymouth, coastwise, in our regular packets, not enumerated therein.

I am, with respect, your obedient servant,

THOMAS LORING,
Collector.

Bvt. Brig. Gen. GEORGE THOM,
Lieut. Col. of Engineers, U. S. A.

A 14.

IMPROVEMENT OF PROVINCETOWN HARBOR, MASSACHUSETTS.

The following amounts have been allotted to and appropriated for the preservation of this harbor since the resumption of work on rivers and harbors in 1866, viz:

Amount allotted in 1866 from appropriation made for harbors on the Atlantic coast	$15,000 00
Amount appropriated by act June 23, 1866	43,068 44
Amount allotted under act of April 10, 1869	9,000 00
Amount appropriated by act of March 3, 1871	6,000 00
Amount appropriated by act of June 10, 1872	5,000 00
Amount appropriated by act of March 3, 1873	6,000 00
Amount appropriated by act of June 23, 1874	6,000 00
Amount appropriated by act of March 3, 1875	5,000 00
Amount appropriated by act of August 14, 1876	4,000 00
Total	99,068 44

Under the above appropriations, the following work has been done to date for the preservation of this harbor, viz:

1. Bulk-heads and jetties of various descriptions have been built from time to time along Beach Point, for its preservation and protection, both by the United States Government and by the local authorities.

2. A dike was built in 1868 and 1869 by the State of Massachusetts across the outlet of East Harbor Creek.

3. A dike was built in 1868 and 1869 by the United States Government across East Harbor Creek at the Wading Place, near High Head, about 2 miles above the outlet of the creek.

4. Wooden bulk-heads and jetties have been built at different times for the protection and preservation of the beach on Long Point.

5. A stone bulk-head has been nearly completed for the protection and preservation of the outer end of Long Point, the light-house, and Three-gun Battery.

6. A substantial dike (272 feet in length) was built in 1871–'72 across the head of Lancey's Harbor, near Abel Hill.

7. Beach-grass planted on Beach Point, Long Point, Abel Hill, Cove Section, and Oblique Section, and at the last two places brush has also been laid for their further protection.

8. The projected extension of the several jetties on Beach Point and State Dike has been completed.

9. A bulk-head and six jetties built for the preservation and protection of the beach at Cove Section, near High Head, were encroached upon by the extraordinary gales of November, 1873, and January, 1874. This bulkhead is 607 feet in length, and the jetties have an aggregate length of 126 feet. They consist of a frame-work filled with brush and ballasted with stone, and were completed in December, 1874.

10. Accurate resurveys made in 1871, 1872, 1873, 1874, and 1875 of Cove Section, Oblique Section, Beach Point, and Long Point, together with elaborate soundings and current-observations in the inner harbor.

The resurveys made of Cove Section in August, 1875, showed that since the completion of the bulkhead and jetties in December, 1874, the sand had accumulated in front of those works to so great an extent that the beach had been raised 4 feet, on an average, between the works and the crest of 1874, and that outside the crest of 1874 the sand had accumulated to an increased height of 11 feet, throwing outward the high and low water lines respectively 90 feet and 105 feet since 1874. A recent inspection of the work showed continued improvement to such an

extent that it is believed that this weak portion of the beach is now secure against further encroachment by storms. These works, however, as well as the dikes at High Head and Abel Hill, and others built for the preservation of this harbor, require continuous watching and repairs. The stone bulkhead, also, on the extremity of Long Point is now being extended farther up the beach as well as around the extremity of the point, to insure its preservation, as well as that of the light-house upon it. The following is an estimate of the cost of the work remaining to be done for completing the projected improvement of this harbor, viz:

1. Raising and extending the stone bulkhead for the protection and preservation of Long Point, near the light-house, and Three-gun Battery, in completion of same	$2,112 00
2. Repairs of bulkhead and jetties on Beach Point and Cove Section	250 00
3. Repairs of dikes at High Head and Abel Hill	250 00
4. Planting beach-grass for preserving and strengthening the outer beach	600 00
Adding for contingencies	958 67
Total	4,170 67
Amount available July 1, 1877	3,170 67
Additional amount required for fiscal year ending June 30, 1879	1,000 00

In regard to the estimates for the work done for the preservation of this harbor, they appear to have generally agreed with the amounts that have been appropriated and expended therefor. Much of the work, however, has been for repairs and extensions not foreseen, but absolutely necessary to be made as they occurred, for which no previous estimates could be made.

Under the appropriation of August 14, 1876, proposals were invited for furnishing large quarry-grout and small rounded bowlders for the bulkhead on Long Point, and in response thereto six bids were received for each; and contracts have been made with the lowest bidders, as follows, viz:

1. With Mr. Alphens C. Peirce, of Rockport, Mass., for 1,000 tons, more or less, of large quarry-grout, at $1.59 per ton of 2,240 pounds, the same to be delivered on or before the 15th of August, 1877; and

2. With Mr. Isaac A. Sylvester, of Quincy, Mass., for 700 tons, more or less, of small rounded bowlders, at $1.48 per ton of 2,240 pounds, the same to be delivered on or before the 30th of August, 1877.

Under the contract made with Mr. Peirce, 558½ tons of large stone have been furnished up to the 1st of July.

Some beach-grass has also been planted on the outer beach, at Cove Section.

Provincetown, in which the above-described works are situated, is a port of entry within the collection district of Barnstable, Mass.

The following information in regard to the revenue and commerce of this port for the year ending December 31, 1876, has been furnished by the United States collector of customs at that place, viz:

Amount of revenue collected for the year	$2,081 29
Amount of exports	12,071 00
Amount of imports	4,739 00
Number of arrivals and departures of vessels, about	11,300

Abstract of proposals received and contracts made during the past fiscal year are hereto appended.

Money statement.

July 1, 1876, amount available	$496 07	
Amount appropriated by act approved August 14, 1876	4,000 00	
		$4,496 07
July 1, 1877, amount expended during fiscal year	437 40	
July 1, 1877, outstanding liabilities	888 00	
		1,325 40
July 1, 1877, amount available		3,170 67
Amount (estimated) required for completion of existing project		1,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		1,000 00

Abstract of proposals received May 26, 1877, for furnishing rubble-stone for the bulkhead on Long Point, Provincetown Harbor, Massachusetts.

Number for reference.	Bidders.	Residence.	Price per ton of 2,240 pounds. Large quarry-grout.	Price per ton of 2,240 pounds. Small rounded bowlders.
1	Alpheus C Peirce	Rockport, Mass	$1 59	$1 69
2	Isaac A. Sylvester	Quincy, Mass	1 68	1 48
3	Charles T. Derry	Sharon, Mass	1 75	1 75
4	Charles H. Bragdon	Biddeford, Me	1 85	1 85
5	Isaac Hamilton	Portland, Me	1 95	1 75
6	Francis Locke	Gloucester, Mass	2 28	2 29

Abstract of contracts made during the fiscal year ending June 30, 1877, for the improvement of Provincetown Harbor, Massachusetts.

Date of contracts.	Contractors.	Nature and location of work.	Price per ton of 2,240 pounds.
		FOR BULKHEAD ON LONG POINT.	
1877. May 31	Alpheus C. Peirce, Rockport Mass	1,000 tons, more or less, large quarry-grout	$1 59
June 4	Isaac A. Sylvester, Quincy, Mass	700 tons, more or less, small rounded bowlders	1 48

APPENDIX B.

ANNUAL REPORT OF MAJOR G. K. WARREN, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1877.

ENGINEER OFFICE UNITED STATES ARMY,
Newport, R. I., July 2, 1877.

GENERAL: I have the honor to forward herewith the annual reports of improvements and surveys of rivers and harbors under my charge for the past fiscal year.

The improvements are thirteen in number. Of these, appropriations are asked for in but five places in order to complete the works already begun, or to make what has been done of benefit. Of these latter, Hyannis Harbor ($10,000) and Taunton River ($5,000) are in Massachusetts. Removing Bulkhead Rock, ($5,000,) is in Rhode Island; Little Narragansett Bay, ($23,000,) is between Rhode Island and Connecticut; and Saybrook Bar, at the mouth of the Connecticut River, ($45,000,) is in Connecticut.

The improvement of Hyannis Harbor is to secure permanence to what has been done, which is to make it a harbor of refuge for the general coasting-trade passing Monomoy and Cape Cod. That of Taunton River is local to the business of that stream, and is to insure 9 feet draught at high-water up to Taunton. Bulkhead Rock is a danger to large vessels bound to Providence, R. I. Little Narragansett Bay is shoal, and the proposed improvement is to dredge a channel through it to facilitate business upon Pawcatuck River, which has been already improved by the United States, and also to facilitate communication between Stonington and the summer-resort at Watch Hill. That at the mouth of the Connecticut River is for the benefit of commerce along its entire valley, and if carried as it may be, to furnish a harbor of refuge for the general coasting-trade.

The improvement of a river and harbor is in these reports considered closed when the works of improvement planned under previous authority of Congress are completed.

The improvement itself cannot be considered complete. As soon as facilities for vessels of a given draught are secured, larger ones begin to seek the new channel or harbor and new demands are made, and though I know this to be the case in many places, I have thought it was not my duty, but that of those interested, to ask for further appropriations for additional facilities.

The harbor at Block Island is a notable instance of this kind. There the breakwater designed for local purposes is demonstrating the importance of extending the work so as to make a harbor for the purposes of general commerce.

There has been no improvement under my charge, except, perhaps, the breakwater at Hyannis, Mass., which has not been largely local in its benefits, benefiting the public mainly in facilitating dealings with that locality. These improvements, however, have commonly been of an inexpensive character, and so distributed as to become, as a system, public.

There is, however, a class of works, mere harbors of refuge, needed along this coast, which are in no sense local and of no special benefit to the locality where placed. They correspond to the first-class light-house on our ocean headlands, or to the removal of such obstructions as the rocks at Hell Gate, or to the improvement of the Des Moines Rapids of the Mississippi.

Several such first-class artificial harbors contiguous to the course of the great stream of coastwise commerce are needed, and it seems to me most desirable that Congress should authorize a board of engineers to consider and report upon this subject for the Atlantic coast.

I make this suggestion because of its public importance, and for the further reason that it cannot originate from local interest as the other works generally do.

Very respectfully,

G. K. WARREN,
Major of Engineers, Bvt. Maj. Gen., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A.

B 1.

HYANNIS HARBOR, MASSACHUSETTS.

The history of the improvement in this harbor, the condition of the breakwater, and the necessity for further appropriation to complete the repairs, are given in my report for 1875. (See report of the Chief of Engineers for 1875, Part II, pp. 266–268.)

Nothing has been done during the fiscal year because of the small amount of money available. The work does not appear to have sustained any notable injury during the year, but it needs strengthening at the base, and it is for this purpose that a further appropriation is required. The estimate for repairs made by me in 1874 was $25,000—of this, but $15,000 have been appropriated.

The light-house should be rebuilt and placed on the east end of the breakwater, as has been suggested in previous reports.

Hyannis is in the Barnstable collection-district. Barnstable is the nearest port of entry. The amount of revenue collected there in the year ending June 30, 1877, is not known to this office.

Money statement.

July 1, 1876, amount available	$42 94
July 1, 1877, amount available	42 94
Amount (estimated) required for completion of existing project	10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	10,000 00

B 2.

WAREHAM HARBOR, MASSACHUSETTS.

A survey of this harbor was made in 1871, and a plan of improvement, including the removal of a ledge and bowlders at the mouth of the Weweantic River, with estimate of cost, was submitted in December of that year by General George Thom, Lieutenant-Colonel of Engineers.

This plan of improvement was for a channel 250 feet in width through Quahaug Bar and 9 feet deep at mean low-water, requiring the removal

of 41,260 cubic yards; and also the widening and straightening of the channel below the Franconia Iron Works, requiring the removal of 45,300 cubic yards. The total of 86,560 yards was estimated to cost, at the rate of 45 cents per cubic yard—

86,560 cubic yards, at 45 cents	$38,952
Contingencies	3,048
Removing ledge and bowlders at Weweantic	3,000
Total	45,000

By act of Congress approved June 10, 1872, $10,000 was appropriated for this work. The work came under my charge June 30, 1872.

A contract for dredging at 34½ cents per cubic yard was made after duly advertising for proposals. Congress by act approved March 3, 1873, appropriated $10,000 for continuing the improvement. A contract for continuing the work was made under this appropriation at 36¾ cents per cubic yard. Under these contracts there was removed:

	Cubic yards.
At Quahang Bar	21,862
At Upper Bar and up to the wharves	24,901
Total	46,763

Also, one bowlder weighing about 28 tons.

During the progress of this improvement another survey was made of the harbor, from which a revised estimate was submitted. The report upon this survey is printed in the report of the Chief of Engineers for 1874, pp. 216–220.

The amount of this revised estimate was $20,000 in addition to what had already been expended; it called for the removal of 41,186 cubic yards from different parts of the channel, and for the removal of rocks to the amount of $3,000 at "Four Buoys," near the entrance to the harbor, although this place had not been included in our surveys.

By act of Congress approved June 23, 1874, $10,000 was appropriated. A contract was made for continuing the improvement at 20 cents per cubic yard, under which 43,514 cubic yards were removed. By act of Congress approved March 3, 1875, $10,000 were appropriated for this work. A contract was made at the rate of 20 cents per cubic yard. Under this contract 33,397 cubic yards were removed.

The whole quantity dredged in this harbor has been:

	Cubic yards.
Up to 1874	46,763
In 1875	43,514
In 1876	33,397
Total	123,674

This quantity is nearly 50 per cent. more than was estimated for, which we were enabled to do on account of the price per yard being less than estimated. The channel made is from 250 to 300 feet wide and 10 feet deep at mean low-water from Long Beach at the entrance of the harbor, up to the upper bar; thence to the bridge at the upper end of the harbor it is from 100 to 300 feet in width and 9 feet deep at mean low-water.

During the past fiscal year a survey was made at the "Four Buoys," where the channel into the harbor passes near a rocky point, which lies about 4,000 feet outside of Long Beach. The channel here for a distance of about 600 feet is about 200 feet in width, with a depth of from 13 to 15 feet at mean low-water. On either side of this channel are

numerous bowlders of varying sizes, lying on the bottom, the removal of which would be attended with an expense far in excess of the benefit to be derived.

We could not learn that any vessel had ever struck them to cause any great damage to themselves. The channel through this reef is marked by four buoys, two at each end. A straight line drawn between the two buoys on the left side of the channel would leave some bowlders on the channel side, but as neither the flood nor the ebb tide sets on this point, it is not regarded as an important matter. The pilots say "we always give the black buoys a good berth coming in," and therefore they have not struck the rocks outside of the line. Above and below the "Four Buoys" there is a good "beating" channel. A map accompanies this report, showing the improvement and the channel at "Four Buoys."

The formation of Quahaug Bar, just inside of Long Beach, is by some people attributed to the sand carried over the beach in storms from the shoal outside. While this may not be the sole cause of the bar, there is a large amount of sand deposited there from this source. To prevent this, it is proposed to use the available funds in building a brush fence along the beach, weighting it with stone found above low-water outside of the beach. This fence is designed to raise the beach above high-water, and by arresting this sand to hold it there permanently.

This improvement will then be completed, and no further appropriation is needed, unless a greater capacity of harbor shall be required than when the plan was adopted.

Wareham is a port of delivery. It is in the New Bedford collection-district, and New Bedford is the nearest port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1876, was $9,710.04.

Money statement.

July 1, 1876, amount available	$7,024 78
July 1, 1877, amount expended during fiscal year	4,967 04
July 1, 1877, amount available	2,057 74

B 3.

NEW BEDFORD HARBOR, MASSACHUSETTS.

The survey upon which the plan and estimate for the improvements were based was made in the summer of 1874, and the report submitted November 30, 1874. This was printed as part of H. Ex. Doc. 75, Part III, Forty-third Congress, second session, and in the Annual Report of the Chief of Engineers for 1875, Part II, pp. 283–285.

With the appropriation of $10,000 made by act of Congress approved March 3, 1875, a channel 105 feet wide and 15 feet deep at mean low-water was made from the deep water near Fair Haven wharves to the deep water at the New Bedford wharves. The line of the new channel was slightly changed from the first design to get better ranges.

The appropriation of $10,000 made by act of Congress approved August 14, 1876, was not made available until April 30, 1877. Advertisement inviting proposals was made May 8, 1877, and on the 8th of June the following were received:

Abstract of proposals received at the Engineer Office, United States Army, Newport, Rhode Island, June 8, 1877, at 10 a. m., for dredging in New Bedford Harbor, Massachusetts.

Number.	Name and address of bidder.	Price per cubic yard.	Commence—	Complete—	$9,000 will pay for cubic yards—
		Cents.			
1	W. H. Molthrop, New London, Conn	$10\frac{1}{4}$	"Soon as required"	November 30	87, 805
2	H. N. & A. J. Beardsley, Bridgeport, Conn	$11\frac{1}{2}$	August 1	December 1	78, 260
3	T. C. Jeffers, Albany, N. Y	13	June 20	November 30	69, 231
4	Morris F. Brainard, Albany, N. Y	$13\frac{7}{8}$	July 1	November 30	64, 864
5	Providence Dredging Co., Providence, R. I	15	June 20	November 30	60, 000
6	John H. Fenner, Albany, N. Y	17	June 20	November 30	52, 941
7	Morris & Cumings Dredging Co., New York City.	20		November 30	45, 000
8	William Flannery, New York City	23	June 20	November 30	39, 130

The contract was awarded to William H. Molthrop, of New London, Conn.

In my last annual report on this work I recommended an additional appropriation of $4,000, to complete the improvement in accordance with the original plan and estimate. The low price at which the work has been contracted for this year will, it is thought, enable us to complete the improvement with the present appropriation.

New Bedford is in the New Bedford collection-district, and is a port of entry. The amount of revenue collected there in the fiscal year ending June 30, 1876, was $9,710.04.

Money statement.

July 1, 1876, amount available	$73 87
Amount appropriated by act approved August 14, 1876	10, 000 00
	10, 073 87
July 1, 1877, amount expended during fiscal year	419 27
July 1, 1877, amount available	9, 654 60

B 4.

TAUNTON RIVER, MASSACHUSETTS.

The only work done on this improvement since the end of the last fiscal year has been the removal of 93.18 cubic yards of rock from Peter's Point and the "Nook."

To make the channel so as to allow vessels of 9 feet draught to reach Taunton at high-water without difficulty will require the dredging of a sand-bar above Berkley Bridge, and the removal of isolated bowlders between the "Needles" and Wickamount. The least width in the cuts is 60 feet.

Sixty thousand dollars have been appropriated and spent for this river. The $5,000 now asked for is an increase above my former estimate for accomplishing the object intended, owing to the discovery of more obstructions.

A history of this improvement may be found in Annual Report of

Chief of Engineers for 1876, Part I, pp. 205, 206, and in Annual Report for 1875, Part II, p. 285.

Taunton is in the Fall River collection-district, and that place is the nearest port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1876, was $6,372.35. The business done in Taunton River is large.

Money statement.

July 1, 1876, amount available	$1,205 90
July 1, 1877, amount expended during fiscal year	1,104 97
July 1, 1877, amount available	100 93
Amount (estimated) required for completion of existing project	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	5,000 00

B 5.

FALL RIVER HARBOR, MASSACHUSETTS.

At the beginning of the fiscal year the amount available for this work was $597.55. By act of Congress approved August 14, 1876, $10,000 was appropriated for it. This appropriation was not made available until April 30, 1877.

Advertisements inviting proposals were issued May 8, and on June 8 the following were received:

Abstract of proposals received at the Engineer Office, United States Army, Newport, Rhode Island, June 8, 1877, at 10 a. m., for dredging in Fall River Harbor, Massachusetts.

Number.	Name and address of bidder.	Price per cubic yard dredging.	Price per cubic yard rock.	Average on basis 2 per cent. rock.	Commence—	Complete—	$9,000 will pay for cubic yards—
1	J. H. Fenner, Albany, N. Y	$0 55	$8 40	.707	June 20	Nov. 30	12,729 1/10
2	William Flannery, New York City	73	8 50	.8854	June 20	Nov. 30	10,167
3	William H. Malthrop, New London, Conn.	93	93	.93	Soon as required.	Nov. 30	9,677
4	Morris & Cumings Dredging Company, New York City.*	98	98	.98	June 20	Nov. 30	9,183 2/3
5	Morris F. Brainard, Albany, N. Y	75	13 00	.9950	July 1	Nov. 30	9,046
6	T. C. Jeffers, Albany, N. Y	1 50	7 00	1.61	June 20	Nov. 30	5,590

* Provided bowlders do not exceed 2 per cent.

A contract has been made with the lowest bidder, John H. Fenner, of Albany, N. Y.

In the plan submitted for the improvement of this harbor in report dated December 31, 1873, (see Annual Report of the Chief of Engineers for 1874, pp. 284–286, Part II,) the estimated cost was $45,000, and $30,000 has been appropriated.

The prices at which the work has been done have been so much less than estimated that the funds now available will complete the improvement as designed, should the bowlders not be more numerous than they have been in the part of the channel already deepened. The improvement designed was to make a channel to and along the wharves 12 feet

deep at mean low-water, the mean tide being 4 feet. This channel is to be about 100 feet wide in the middle, widening to 300 feet at each end. Before it was begun the depth varied from 5 to 12 feet.

Fall River is in the Fall River collection-district, and is a port of entry.

The amount of revenue collected there during the fiscal year ending June 30, 1876, was $6,372.25.

Money statement.

July 1, 1876, amount available	$597 55
Amount appropriated by act approved August 14, 1876	10,000 00
	10 597 55
July 1, 1877, amount expended during fiscal year	341 08
July 1, 1877, amount available	10,256 47

B 6.

PAWTUCKET OR SEEKONK RIVER, RHODE ISLAND.

No work has been done in this river during the past fiscal year. The remainder of the last appropriation is reserved to deepen certain shoals, which are reforming, or for the removal of any accidental obstruction which may take place.

For a history of this work see Annual Reports of the Chief of Engineers for 1874, Part II, p. 227, and for 1876, Part I, p. 207.

Pawtucket River is in the Providence collection-district, and that place is the nearest port of entry.

The amount of revenue collected there during the fiscal year ending June 30, 1876, was $182,352.57.

Money statement.

July 1, 1876, amount available	$1,594 61
July 1, 1877, amount expended during fiscal year	83 33
July 1, 1877, amount available	1,511 28

B 7.

BULKHEAD ROCK, PROVIDENCE RIVER, RHODE ISLAND.

The removal of the rock to 18 feet depth at mean low-water is of importance to vessels entering or leaving the harbor of Providence.

Under the appropriation of $2,500 made in 1870 it was removed to 14 feet at mean low-water, but this depth is not enough.

Providence River is in the Providence collection-district. Providence is the nearest port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1876, was $182,352.57.

Money statement.

July 1, 1876, amount available	$74 98
July 1, 1877, amount available	74 98
Amount (estimated) required for completion of existing project	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	5,000 00

B 8.

NEWPORT HARBOR, RHODE ISLAND.

The improvement of this harbor was essentially completed last year as far as designed. (See Annual Report of the Chief of Engineers for 1873, pp. 964–967.)

The small amount on hand at the beginning of the fiscal year had been reserved for contingencies, and with it we, assisted by the naval officers at the United States torpedo-station and by the Old Colony Steamboat Company, removed a large bowlder from the channel between the south end of Goat Island and Lime Rock light. This bowlder had but 11 feet on it at mean low-water, and in extraordinary low run of tides not more than 9 feet.

The steamboats have occasionally struck something in coming into the harbor, but it being at night and the vessel never sticking, the location of the obstruction and its nature had been a matter of conjecture. Last winter the large steamboat Bristol, in entering the harbor at time of very low water, struck on it so hard as to tear off a large amount of copper. The divers employed to examine her bottom reported that she must have struck a rock or an anchor. We then swept this part of the channel with two boats and a weighted line between them. This line after repeated trials caught, and a diver was sent down, and reported a bowlder about 12 feet by 13 feet, and 5 feet above the bed. He brought up several pieces of copper similar to that on the Bristol. The rock was then shaken to pieces with charges of dynamite by Prof. W. N. Hill, of the torpedo station. The pieces were raised so as to leave a depth of 15 feet at mean low-water. In sweeping for this rock a can-buoy was found, which was raised and returned to the Light-House Department.

Another large bowlder, having but 9 feet on it at mean low-water, where the depth around it was 11 feet, was removed from the inner harbor. This rock had to be broken with dynamite, like the other, before the schooner employed could raise it.

The improvement of this harbor has been made by dredging a channel along the new harbor-line, with an approach 250 feet wide in the middle part, and one 50 feet wide at the north side. Along the harbor-line the width varies from 85 to 105 feet, and the depth from 12 feet in the middle portions to 10 feet at the ends. Wharf-owners have now the opportunity of dredging from the new channel in to their wharves, or extending the latter out to the channel. A jetty was also built at the south end of Goat Island, which has served effectually to prevent the shore-sands and gravel from drifting into the inner harbor.

No further improvement of the harbor is needed at present for its local business, except what should be done by private parties.

The whole outer shore of Goat Island should, however, be protected by short jetties or by a sea-wall.

Newport is in the Newport collection district, and is a port of entry. The amount of revenue collected during the fiscal year ending June 30, 1876, was $258.20.

Money statement.

July 1, 1876, amount available	$954 06
July 1, 1877, amount expended during fiscal year	923 92
July 1, 1877, amount available	30 14

B 9.

BLOCK ISLAND HARBOR, RHODE ISLAND.

At the beginning of the present fiscal year the amount of funds available for this work ($22,447.70) was too small to commence the building of the detached pier, which, unless completed, would prove a dangerous obstruction.

By act of Congress approved August 14, 1876, $40,000 was appropriated, but this was not made available until February 7, 1877.

Advertisements were issued February 22 inviting proposals for furnishing granite for continuing the work. On the 22d of March the following proposals were received:

Abstract of proposals received at the engineer office, United States Army, Newport, Rhode Island, March 22, 1877, at 10 a. m., for furnishing riprap-granite for Block Island breakwater.

Number.	Name and address of bidder.	Price per ton, 2,240 lbs.	Commence—	Complete—	$45,000 will pay for tons—
1	Patrick Harrington & Co., Groton, Conn	$1 29	May 1, 1877	Nov. 30, 1877	34,573
2	Simeon A. Chapman and A. D. Cook, Groton, Conn	1 43	May 1, 1877	Nov. 30, 1877	31,648
3	F. H. Ingerson and W. H. Molthrop, New London, Conn.	1 55	Apr. 15, 1877	Nov. 30, 1877	29,032
4	Francis H. Smith, New York City*	1 69	May 1, 1877	Nov. 30, 1877	26,627
5	Ballou & Sylvester, Boston, Mass	1 69	May 1, 1877	Nov. 30, 1877	26,627
6	Samuel Dale and Levi Moses, Springfield, Mass	1 69	May 1, 1877	Nov. 30, 1877	26,627
7	Beattie & Dresser, Guilford, Conn	1 70	May 1, 1877	Dec. 30, 1877	26,470
8	D. V. Howell, New York City†	1 77	May 1, 1877	Nov. 30, 1877	25,424
9	Asa C. Palmer, Fayetteville, N. Y.†	1 88	May 1, 1877	Nov. 30, 1877	23,937
10	John F. Hamilton, Portland, Me.†	2 00	May 1, 1877	Nov. 30, 1877	22,500
11	Staples & Phillips, Taunton, Mass	2 08	May 1, 1877	Nov. 30, 1877	21,634
12	Clinton Stephens, New York City	2 20	May 1, 1877	Nov. 30, 1877	20,454
13	Swift & Linker, Providence, R. I	2 20	May 1, 1877	Nov. 30, 1877	20,454
14	Emil von Trentini, New York City	2 20	May 1, 1877	Nov. 30, 1877	20,454
15	John L. Hopkins, Vinal Haven, Me.‡	2 90	May 1, 1877	Nov. 30, 1877	15,517
	Colby & Trumbull, Lawrence, Mass.§	2 32	May 1, 1877	Nov. 30, 1877	19,396

* Guarantors' signatures not witnessed.
† Signature to proposal not witnessed.
‡ Guaranty not properly made out.
§ Received at 10.50 a. m.; not considered.

The contract was awarded to Patrick Harrington & Co., of Groton, Conn., at $1.29 per ton. They commenced work in May, and up to this date have placed 9,041.35 tons in the main work and in the detached piece.

The work of putting in stone will be continued through the season. In addition to this work, it is proposed to employ a vessel with hoisting apparatus and divers to remove bowlders from the anchorage sheltered by the breakwater.

The funds now available are thought to be sufficient to complete the smaller breakwater designed for the business of the island.

The original survey, upon which estimates were made for this work, was made under direction of Col. D. C. Houston, United States Engineers, in 1867.

A board of engineers was convened under date of February 18, 1868, to report plans and estimates for this work. Their report was published as Senate Mis. Doc. No. 81, Fortieth Congress, second session.

Estimates were made by this board for three breakwaters:

First. One for a harbor large enough for a shelter for the largest vessels, the estimated cost of which was about $3,000,000.

Second. A breakwater for a harbor for local purposes, to extend from the shore out 500 feet to "5-foot rock," to cost $372,000.

Third. A breakwater for a harbor for local purposes, to extend to a point 300 feet beyond "5-foot rock," to cost $553,798.

The breakwaters for local purposes, estimated for by this board, were to be of riprap-stone, with the outer or seaward slope faced with stone of from 2 to 5 tons weight, and to be surmounted by a parapet or wall of cut stone above low-water.

The work of construction was commenced in October, 1870, by throwing in riprap-stone. The season's work demonstrated that, to carry on this work cheaply, shelter must be had for vessels engaged on the work. This was done by building a timber-crib in the shore-angle of the breakwater, inclosing an area about 250 by 300 feet, with an entrance 60 feet wide; this inclosure was dredged to 7 feet depth at mean low-water. The rise of the tide being about 3.2 feet, vessels drawing 10 feet can enter this basin at high-water.

Instead of surmounting the breakwater with a parapet of cut stone, as proposed by the Board of Engineers, we have built it to the required height with riprap or quarry stone, thereby effecting a considerable saving in the cost of the work.

The present condition of the work is as follows: The main breakwater is completed to a point 500 feet beyond the "5-foot rock," and 1,325 feet from the south side of the inner harbor or basin; this it is proposed to extend about 50 feet farther.

The detached piece was commenced at a point 200 feet beyond, and on line with the outer end of the main work.

The detached piece makes an angle of 15° to the left at a point about 50 feet from the south end, and an additional 15° at a point 100 feet from the south end; from this point it is to be continued in a straight line as far as this contract for stone will build it. The present length of the detached pier is about 90 feet. It will probably be about 250 feet in length on completion of this contract.

The following appropriations have been made for this work:

July 1, 1870	$30,000
March 3, 1871	75,000
June 10, 1872	50,000
March 3, 1873	50,000
June 23, 1874	20,000
March 3, 1875	20,000
August 14, 1876	40,000
Total	$285,000

In justice to the engineering of this work, it should be considered finished, according to the original plan of procuring sufficient shelter for the use of the business of the island. More shelter has been secured, and at a cost much less than estimated. Like all such works, it will in time need repairs, and like all such improvements, too, there will probably be a need of extending it, for it has become the resort of numbers of fishing-vessels not connected with the island, and they sometimes quite fill the harbor. The mackerel-fishermen and menhaden-fishermen would at times fill up a harbor of double the present capacity, and it will undoubtedly be sought by ordinary coasters, to properly accommodate which would require a harbor not less than four or five times the present capacity.

The increase of area for anchorage can probably be doubled or trebled by removing bowlders and dredging, and as far as the enlargement can

be made in this way it is probably cheaper than by extending the breakwater.

At the close of this season's work it is proposed to submit a final report, reviewing the subject in detail, and giving plans and estimates of cost of meeting the probable wants of the future.

Block Island is in the Newport collection-district. Newport is the nearest port of entry. The amount of revenue collected during the fiscal year ending June 30, 1876, was $258.20.

Money statement.

July 1, 1876, amount available	$22,447 70	
Amount appropriated by act approved August 14, 1876	40,000 00	
		$62,447 70
July 1, 1877, amount expended during fiscal year	13,136 07	
July 1, 1877, outstanding liabilities	2,332 67	
		15,468 74
July 1, 1877, amount available		46,978 96

B 10.

PAWCATUCK RIVER, RHODE ISLAND AND CONNECTICUT.

The projected improvement of this river, viz, a channel 75 feet wide and 5½ feet deep, was completed and reported on in my last annual report, since which time nothing has been done. The small balance from the last appropriation I have reserved to meet any contingency that might arise from the sinking of a vessel or other obstruction of the channel. A history of the improvement of this river is given in Annual Report of the Chief of Engineers, 1876, Part I, pp. 210, 211.

The Pawcatuck River is the dividing line between the Stonington and Providence collection-districts. Stonington is the nearest port of entry. The amount of revenue collected during the fiscal year ending June 30, 1876, was $1,284 at Stonington, and $182,352.57 at Providence.

Money statement.

July 1, 1876, amount available	$176 37
July 1, 1877, amount expended during fiscal year	74 40
July 1, 1877, amount available	101 97

B 11.

LITTLE NARRAGANSETT BAY, RHODE ISLAND AND CONNECTICUT.

Congress, by act, approved March 3, 1875, authorized a survey of this bay to be made. This survey was made by me, in accordance with instructions dated March 22, 1875, in the summer of 1875, and reported on under date of November 30, 1875. (See Report of Chief of Engineers for 1876, Part I, pp. 217–221.) The improvement recommended by me in this report was a channel 200 feet wide and 7½ feet deep at mean low-water, to be located along the north shore of the bay, to avoid the danger of being filled by shifting sands, and to give good sailing-ranges. This channel was to be made by dredging. In addition to the dredging

Work was commenced on June 19, and continued during the month. The complete removal will probably be effected early in July.

The dredging on the bars between Hartford and the mouth of the river will probably have to be continued through July and August. There will then be about $5,000 or $6,000 available for this work; an amount too small to do much toward completing the improvement at the mouth of the river; and it is desirable to reserve it to remove any other obstruction which may get into the existing channel, such as wrecks or shoals, before Congress makes additional provisions.

The case of the Connecticut River is one which should always be provided with a contingent fund. I would urgently recommend the granting at once of a sufficient sum to complete the jetties at Saybrook Bar. It is not unlikely that the east jetty may have to be extended upward to increase the flow of the water between the jetties, and it may be necessary to carry a layer of stone across the river to the east of the jetties.

There seems every reason to believe that the bar at the mouth of the Connecticut River, owing to the strong littoral current produced by the tides in Long Island Sound, is specially adapted to improvement by means of jetties, and that a depth at mean low-water of 14 feet may be secured, when the jetties are completed, by auxiliary works, to throw more water between them, if there is not enough as at present designed.

In the unfinished condition, however, they are of little use. It seems to be a case whose public importance justifies a very liberal expenditure, and as all of the last appropriation of $20,000 has been needed elsewhere on the river and in keeping up repairs here, I have renewed my former estimate of $45,000 for Saybrook Bar.

The Connecticut River below Hartford is in the Middletown collection-district. Middletown is the nearest port of entry.

The amount of money collected there during the fiscal year ending June 30, 1876, was $19,956.14.

Money statement.

July 1, 1876, amount available	$165 42
Amount appropriated by act approved August 14, 1876	20,000 00
	20,165 42
July 1, 1877, amount expended during fiscal year	9,451 67
July 1, 1877, amount available	10,713 75
Amount (estimated) required for completion of existing project	45,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	45,000 00

B 13.

CONNECTICUT RIVER ABOVE HARTFORD, CONNECTICUT, AND BELOW HOLYOKE, MASSACHUSETTS.

The condition of the river has been such as to require no expenditure for improvements during the fiscal year ending June 30, 1877. If any shoals or other obstructions should give trouble to such vessels as can pass the Enfield Falls during the present year, the available funds will be used for their removal, and they are deemed sufficient to meet any such contingency. A thorough improvement of the Enfield Falls, as already reported, is a necessary preliminary to any increase in the navigable

capacity of this river above Hartford. This alone will cost from $800,-000 to $900,000.

To make a thorough improvement of the river between Hartford and Enfield Falls will cost between $2,000,000 and $3,000,000.

MONEY HERETOFORE APPROPRIATED FOR THIS IMPROVEMENT.

One-half of amount appropriated for Connecticut River, June 11, 1870	$20,000
Above Hartford and below Holyoke, March 3, 1871	20,000
Above Enfield Falls and below Holyoke, June 10, 1872	25,000
Above Hartford and below Enfield Falls, March 3, 1873	20,000
Total	$85,000

Of these, the first was expended upon wing-dams; the second has been partly expended upon surveys and dredging; the third has been partly expended upon surveys and dredging; the fourth has been partly expended upon surveys.

The amounts appropriated have been wholly inadequate to making any thorough river improvement, and so there was means for making thorough surveys. As far as needed these surveys have now been made.

In my last annual report upon this work, I stated that it was desirable to have the reports made upon surveys of this part of the river during the progress of the improvement published in a combined report, with the maps and diagrams. It does not seem probable that the money appropriated for this river above Enfield Falls and below Holyoke will be needed for improvement, and I suggest that so much as is necessary be used in publishing these maps and a full report. The maps have been already prepared for photolithographing.

After this is done, I recommend that all the money appropriated for the river above Hartford (reserving $5,000 for the shoals between Hartford and Enfield Falls) be, by law, transferred to the improvement of the bar at the mouth of the river.

Connecticut River is in the Middletown collection-district. Middletown is the nearest port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1876, was $19,956.14.

Money statement.

Above Hartford, Connecticut, and below Holyoke, Massachusetts.

Act of March 3, 1871:	
July 1, 1876, amount available	$3,831 83
July 1, 1877, amount expended during fiscal year	541 40
July 1, 1877, amount available	$3,290 43

Above Enfield Falls, Connecticut, and below Holyoke, Massachusetts.

Act of June 10, 1872:	
July 1, 1876, amount available	$10,702 92
July 1, 1877, amount available	10,702 92

Above Hartford and below Enfield Falls, Connecticut.

Act of March 3, 1873:	
July 1, 1876, amount available	$12,272 04
July 1, 1877, amount available	12,272 04
Total available above Hartford July 1, 1877	$26,265 39

APPENDIX C.

ANNUAL REPORT OF MAJOR J. W. BARLOW, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1877.

ENGINEER OFFICE, UNITED STATES ARMY,
New London, Conn., July 11, 1877.

GENERAL: I have the honor to transmit herewith the reports of river and harbor works in my charge for the fiscal year ending June 30, 1877.

Very respectfully, your obedient servant,

J. W. BARLOW,
Major of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A.

C 1.

STONINGTON HARBOR, CONNECTICUT.

No appropriation for the year ending June 30, 1877, was made for this harbor.

The project for a breakwater on Wampassett Shoal, 683 yards in length, recommended by a board of engineers, was approved by the Department, and the appropriation of $25,000 made by act of Congress, approved March 3, 1875, was expended in building a portion of this structure, about 257 yards long. This short length of breakwater covers but a limited anchorage; it should be extended at as early a date as practicable in order that any real benefit may be derived from the project adopted and the money already expended in the partial execution.

An appropriation for the next fiscal year is therefore specially desirable.

Stonington Harbor is in the Stonington collection-district. The amount of revenue collected there during the fiscal year ending June 30, 1877, was $1,450.60.

Following is a list of the several appropriations since the report on the survey of 1871:

March 3, 1873, dredging between old breakwater and steamboat dock....	$25,000 00
June 23, 1874, dredging on Penguin Shoal....	20,000 00
March 3, 1875, commencement of breakwater at Wampassett Shoal......	25,000 00
Original estimate made in June, 1875, for completing the present project.	231,000 00

COMMERCIAL STATISTICS.

The following statements have been received from Captain Hubbard, collector of the port.

Statement of vessels entered and cleared in this district, year ending June 30, 1877, with draught 3 to 17 feet.

	Number.	Average value.	Tonnage.
Steamers entered	314	$75,000	629,416
Steamers cleared	314	70,000	629,416
Sail-vessels entered	11	....	1,207
Sail-vessels cleared	6	....	914
Steamers arrived without entry	10	....	13,000
Steamers departed without entry	10	....	13,000
Total	....	....	1,286,953

Arrivals harbor of refuge, coasting-vessels	1,682
Arrivals harbor of refuge, fishermen	500
Total	2,182

Steamers arrived with passengers, 67. Tonnage, 20,100.
Approximate amount of revenue paid into the Treasury from 1870 to 1877, $20,000.

Number of vessels passed "light-ship," for year ending June 30, 1877.

Months.	Ships.	Barks.	Brigs.	Schooners.	Sloops.	Steamers.	Total.
July	1	....	4	1,366	583	387	2,341
August	5	2	8	1,442	548	354	2,359
September	3	3	12	1,604	674	405	2,701
October	....	2	11	1,505	563	365	2,446
November	....	....	6	1,534	387	320	2,247
December	....	1	4	572	79	177	833
January	1	1	....	145	53	160	360
February	....	....	1	510	198	182	891
March	....	5	6	923	256	191	1,381
April	2	2	6	1,566	384	297	2,257
May	2	1	4	1,864	691	378	2,940
June	2	1	2	1,531	627	339	2,502
Totals	16	18	64	14,562	5,043	3,555	23,258

Captain Hubbard also states that vessels bound eastward are subject to great inconvenience and loss of time in being obliged, in case of heavy weather, to return to New London for a harbor; that were the contemplated improvements at Stonington completed, such vessels would find a secure anchorage 15 miles nearer their destination, and at the most easterly point of Fisher's Island Sound, whence the open sea could be reached in a few moments' sail.

Money statement.

July 1, 1876, amount available	$959 75
July 1, 1877, amount expended during fiscal year	915 12
July 1, 1877, amount available	44 63
Amount (estimated) required for completion of existing project	206,536 60
Amount that can be profitably expended in fiscal year ending June 30, 1879.	50,000 00

C 2.

THAMES RIVER, CONNECTICUT.

A petition from citizens of Norwich and New London for the removal of bars on this river was transmitted to the Department with a letter

dated February 3, 1877. A personal inspection of the localities has since been made, which substantially confirms the opinions therein expressed. Shoals were found to obstruct the 11-foot channel completed in 1873, to the following extent:

From Perch Rock to Bushnell's Reef, a distance of about 800 feet, the depth is 9 to 10½ feet. Between piers H and G, 8½ to 10 feet; above pier D, 9 feet. Near the stove-foundery, just below Norwich, the channel has become much narrowed by a shoal which has made out from the position of the Middle Ground, seriously impeding the movement of steamers while rounding to, to reach their wharf.

The Middle Ground, dredged to 9 feet depth, has now in places a depth of but 6 feet at mean low-water. Without making an instrumental survey, the amount of material necessary to be removed to restore the dredged channel to the dimensions originally given to it cannot be estimated with any great degree of accuracy. From my recent examination, however, I am convinced that the removal of these recent obstructions is greatly needed. It might perhaps be advisable to commence work with a less sum than was recommended in my letter of February 3, to be applied after making an instrumental examination of the shoals to those points where most needed. A satisfactory report could then be made, based upon the information derived from the survey and the first season's work. The survey should cost not to exceed $300. For this purpose and to commence dredging an appropriation of $6,000 is recommended.

The following sums have been appropriated for the improvement of this river:

Expended in the construction of piers or wing-dams:	
1836	$10,000 00
1837	20,000 00
1838	10,000 00
Expended in dredging channel 100 to 200 feet wide and 11 feet deep at mean low-water:	
1866–'67	82,000 00
1871	15,000 00
1872	10,000 00
Total	147,000 00

The plan at first adopted by the General Government and executed during the years 1836–'37–'38 was the construction of piers for the purpose of contracting the channel at the shoals, with a view to create a scour by the increased current of the river. For this purpose $40,000 was expended. These piers do not seem to have had the desired effect, and in 1866 dredging was begun and continued through several seasons, closing in 1873. The channel then obtained was considered sufficient for the traffic of the river. The dimensions then given it is now desirable to restore. Norwich is at the head of navigation on this river.

The following statement has been received, showing the amount of freight, &c., which arrived by river during the year ending June 30, 1877:

Coal, iron, and sand, 200,000 tons, more or less.
Brick and lime, 2,000 tons, more or less.
Lumber, 18 to 25 cargoes, 4,000 tons, more or less.
Vessels average 300 tons burthen.
Draught of water, 8 to 11 feet.
West India cargoes lighter at New London. There is a daily line of steamers carrying passengers and freight to New York, and a weekly freight-propeller.

New London, at the mouth of the Thames, is a port of entry, where the following collections were made during the last fiscal year:

Duties on imports	$55,908 59	coin.
Tonnage-dues	637 50	currency.
Hospital-dues	1,838 29	currency.
Light-boat-inspector's fees	3,886 10	currency.
Total	62,270 48	

Forts Trumbull and Griswold are located near the mouth of this river, and also the New London light-house.

C 3.

NEW HAVEN HARBOR, CONNECTICUT.

During the fiscal year ending June 30, 1876, 43,606 cubic yards of material had been removed in widening the channel between Long Wharf and Belle Dock; the contract was then about half completed. Upon the approval of my recommendation the time for completing this contract was extended three months. From July 1, to the close of the work on the 26th of August, 1876, there was removed from the south side of the channel 45,725 cubic yards of sand, mud, and shells, making a total during the season of 89,331 cubic yards, and giving a channel 415 feet wide and 13 feet deep at mean low-water. In my annual report for the fiscal year ending June 30, 1876, reference is made to a letter dated January 25, 1875, and printed in Appendix Z of the annual report of the Chief of Engineers for 1875, which contains estimates for widening and deepening the main channel and for a breakwater near the entrance to the harbor, and to these I would now respectfully refer, renewing my recommendation therein contained. Should it not be considered expedient to enter at this time upon a project involving so large an expenditure, I would respectfully submit that so far as this project pertains to widening and deepening the main channel, any sum expended in dredging would accord with the project, and at the same time give immediate relief to the shipping interests of the harbor.

The channel between Fort Hale and Steamboat wharf which is now but 200 feet wide, does not afford sufficient space for convenient navigation, and it is therefore respectfully recommended that an appropriation be asked to widen this part of the channel to 400 feet, with a depth of 16 feet at mean low-water. The channel above Long Wharf having been widened last year, a continuous harbor of not less than 400 feet in width would then be obtained. It is estimated that $40,000 would suffice at the present low prices for dredging, to accomplish the above improvement, and this sum could be profitably expended during the ensuing year.

LUDDINGTON ROCK.

In my annual report for the year ending June 30, 1876, it was shown that there yet remained 294 cubic yards of sand, loose stone, and rock, to be removed before the required depth (16 feet) could be attained. This the contractor had repeatedly expressed his intention of removing, but subsequently declining to have anything more to do with the matter, nothing has since been done.

New Haven is the port of entry of the collection-district of New Haven.

The following statement showing the transactions at the port of New Haven has been received from the collector of customs:

Collections:	
Duties on imports	$365,081 10
Tonnage-tax	1,974 00
Hospital-tax	2,213 93
Miscellaneous receipts	4,127 70
	373,396 73

Number of foreign vessels arrived from foreign ports	28
Cleared for foreign ports	24
American vessels arrived from foreign ports	65
Cleared for foreign ports	24
Total number of steamers, sail-vessels, and barges entered and cleared during the fiscal year ending June 30, 1877	6,422
Draught of water from 7 feet to 12 feet.	
Total tonnage	1,397,700
Estimated value of cargoes	$105,900,000
Estimated number of vessels of all classes entering the harbor for refuge during the year	4,500

The following amounts have been appropriated for the improvement of New Haven Harbor since 1866:

July 11, 1870—Work on Middle Rock and beginning at 13-foot channel, 200 feet wide, from Fort Hale to Long Wharf, and 100 feet wide to Belle Dock	$15,000 00
March 3, 1871—Completing the above channel and working on Luddington Rock	40,000 00
June 10, 1872—Beginning channel 200 feet wide, 16 feet deep, from Fort Hale to light-house	20,000 00
Removal of Luddington Rock	15,000 00
March 3, 1873—Completing channel from Fort Hale to light-house, and widening channel from Long Wharf to Belle Dock	25,000 00
March 3, 1875—Widening to 400-foot channel from Long Wharf to Belle Dock	10,000 00

Money statement.

July 1, 1876, amount available	$11,697 34
July 1, 1877, amount expended during fiscal year	9,085 21
July 1, 1877, amount available	2,612 13
Amount that can be profitably expended in fiscal year ending June 30, 1879.	40,000 00

C 4.

MILFORD HARBOR, CONNECTICUT.

At the close of the fiscal year ending June 30, 1876, the contractor for dredging in this harbor had removed 18,799 cubic yards of material.

A two months extension of the contract was granted, and work continued until July 29, when 5,433 cubic yards in addition had been removed, making a total of 24,232 cubic yards. The dredged channel was made 75 feet wide, from the 4-foot curve at the mouth of the harbor to a point about 800 feet above the long jetty, or 300 feet below W. Merwin's dock. The dredging should be continued until a channel 50 feet wide and 4 feet deep at mean low-water has been made to the town dock, a

distance of about a half-mile from the head of last season's work, and would require the removal of about 45,000 cubic yards, at an estimated cost of 20 cents per cubic yard, or $9,000 for the work, including contingencies and superintendence.

The long jetty at the mouth of Indian River was nearly completed at the close of the last fiscal year; 3,698 tons of stone were used in the work up to that time. During the month of July, 1876, 400 tons of stone were placed in position, and the wall completed with the exception of about 125 feet of coping. The amount of stone required to complete the work is about 65 tons, at an estimated cost of $3 per ton. This jetty has received no material injury during the winter. A few stones have been dislodged where the coping is lacking, but these can be replaced at a trifling expense.

An inspection of the dredged channel was made in April, 1877, with the following result:

During the winter a new bar, with a depth varying from 6 to 18 inches, has formed across the dredged channel at a point about 200 feet above the long jetty. This bar is caused by the bringing down of material loosened by and made subject to the action of the current of Indian River, which joins the Wopowang at nearly a right angle. The effect has been to deepen the Indian River channel some distance back from its junction with the Wopowang, the material washed out being carried into the latter. This material, mostly gravel, cannot be carried away by the weaker current of the Wopowang.

It may appear singular that the combined currents of the two streams should have less scouring effect than the Indian River branch, but this is owing to the considerable fall of the latter before reaching the junction, increased by the new depth of the channel dredged below its debouché.

The formation of this bar is not regarded as a serious matter, and it is believed that if it should now be removed there is little probability of its forming again.

The channel has maintained its depth below the long jetty, as was anticipated; the jetties at Welch's Bluff are fulfilling all that was expected of them, preventing erosion of the banks and arresting the movement of sand to the westward. Upon an inspection of the jetties it was found that the ice and severe storms of the past winter had seriously damaged them. The outer ends were leveled, some of the large stone, weighing from 1 to 2 tons each, being thrown a distance of 10 or 12 feet, while the inner ends, being protected by the sand and drift which had made in the angles formed by the jetties with the beach, were but slightly damaged.

The only sure protection for this work would be to build a breakwater of heavy riprap-stone from Welch's Point to deep water. This would not only preserve the dredged channel, and with the assistance of the jetties protect the banks from erosion, but would afford a harbor of refuge for the many vessels passing up and down Long Island Sound, and a secure place for vessels to lie, bound to Derby, Birmingham, or Shelton, while waiting for high-water to cross the bar at the mouth of the Housatonic River.

In 1872, General Warren made an estimate for a breakwater from Welch's Point, to contain 24,290 tons of riprap-granite, in pieces of a ton and upward in weight, to have a triangular cross-section sloping 45° each side, to rise 9 feet above mean low-water, and to extend to the curve of 15 feet depth, being 890 feet long, at an estimated cost at that time of $67,000. The work could now be built for about $45,000, and

I respectfully renew previous recommendations respecting its expediency.

The following amounts have been appropriated by Congress and expended on the improvement of Milford Harbor:

June 23, 1874	$5,000 00
March 3, 1875	13,000 00

Original estimates for this harbor, made in 1872, are—

For breakwater at Welch's Point	$67,000 00
Jetties at Welch's Bluff	5,000 00
Long jetty and dredging	13,000 00
	85,000 00
1876, additional estimate for continuing dredging	8,000 00

Milford is in the New Haven collection district, New Haven being the nearest port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1877, was $373,396.73.

The following number of vessels are reported as arriving with cargoes during the year ending June 30, 1877:

Number of vessels, 90; draught, 4 to 8 feet; tonnage, 4,000; value of cargoes, $50,000. Number of steam-vessels arrived, 40.

A great number of vessels are employed continually in the oyster and oil trade, which are not included in the above; also, since the improvements have begun, the harbor has afforded shelter for a very large number of vessels.

Money statement.

July 1, 1876, amount available	$4,706 65
July 1, 1877, amount expended during fiscal year	4,260 81
July 1, 1877, amount available	445 84
Amount (estimated) required for completion of existing project	64,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	25,000 00

C 5.

HOUSATONIC RIVER, CONNECTICUT.

March 3, 1875, an appropriation of $5,000 was made for the improvement of this river.

It was deemed most expedient to expend this money in dredging.

After obtaining prices from various dredge-owners, a dredge and tug with the necessary scows, suitable for doing the work, was hired of Mr. Morris F. Brainard, of Albany, N. Y., for $6 per hour, actual working time. Work was begun June, 1876, on the shoal formed during the winter and spring above and below Drew's Rock, and continued until August 16, 1876. During this time 21,682 cubic yards of sand were removed, making the dredged channel 60 to 80 feet wide and 7 feet deep at mean low-water above the rock, and of an average width of 40 feet and depth of 7 feet below the rock. The cost of removing the material was about 16½ cents per cubic yard. No examination has been made of this shoal since the close of the work, but if it should be found after an examination that the channel has filled, it is respectfully recommended that the rock and jetty be removed.

The jetty at Drew's Rock was built in 1872, at a cost of about $725.

By building it the greater expense of removing the rock, estimated at $6,285, was avoided, and it was thought that the advantages to navigation would be practically the same. This, however, has not proved to be the case. The strong current of the ebb-tide in times of freshet sweeping round the end of the jetty, has cut a deep hole. After passing it, the velocity slackens, and, by reason of the increased flowage area, the material which has been held in suspension and carried along by the current is deposited and a bar formed.

Mr. Henry Harding, assistant engineer, in making a report to General Warren, under date of January 1, 1872, on a survey looking to the removal of the rock, estimated the amount necessary to be removed to give a depth of 7 feet at mean low-water as 419 cubic yards. The amount of stone used in the construction of the jetty was 426.3 cubic yards, at $1.70 per cubic yard. The rock in place could be removed at a cost not to exceed $10 per cubic yard, and the riprap composing the jetty at a cost not exceeding 50 cents per yard, by using a grapple-dredge.

During the past winter, the bar at the mouth of the river has filled so that at the present time there is 12 inches less water than a year ago.

No appropriation was made for the fiscal year ending June 30, 1877. An appropriation of $5,000 is respectfully recommended for the next fiscal year to remove deposits likely to have formed during the winter and spring freshets.

Housatonic River is the dividing line between New Haven and Fairfield collection districts. The amount of revenue collected during the year ending June 30, 1877, was, at Bridgeport, the nearest port of entry, $2,966.16.

The following is a report of shipping at the port of Derby, Conn., for the fiscal year ending June 30, 1877.

During this period there arrived—

No. of barges and vessels.	Cargoes.	Quantity.	Value.
61	Coal ... tons	13,688	$76,000
6	Jute ... do	758	11,400
6	Iron ... do	988	44,000
2	Sand ... do	228	700
1	Ashes ... do	225	900
12	Bricks ... M	425	2,400
2	Lumber ... feet	325,000	3,900
1	Shells ... tons	130	175
1	Blue-stone ... do	80	450
8 small sloops, miscellaneous cargoes			500
Total			140,425

The following appropriations have been made for improvements on this river:

March 3, 1871	$15,000 00
June 10, 1872	15,000 00
March 3, 1873	10,000 00
June 23, 1874	10,000 00
March 3, 1875	5,000 00

Estimates for the improvement of this river have been made from year to year, with the object of removing bars formed by the winter and spring freshets.

Money statement.

July 1, 1876, amount available	$4,460 11
July 1, 1877, amount expended during fiscal year	4,442 38
July 1, 1877, amount available	17 73
Amount that can be profitably expended in fiscal year ending June 30, 1879	5,000 00

C 6.

BRIDGEPORT HARBOR, CONNECTICUT.

No work was done at this harbor during the last fiscal year.

By act of Congress, approved August 14, 1876, $10,000 was appropriated for the improvement of the harbor at Bridgeport, Conn., but no authority to expend this amount was granted until April 27, 1877.

Bids for dredging were opened June 21, 1877, and the contract awarded to Messrs. H. N. and A. J. Beardsley, at 8⅞ cents per cubic yard, the work to be done between the steamboat wharf and the wagon-bridge. It is hoped that the project for widening the 12-foot channel on the outer and inner bars to 300 feet will be continued, and for this purpose $20,000 could be profitably expended during the next fiscal year.

Following is a statement of the amounts appropriated for Bridgeport Harbor:

March 3, 1871	$20,000 00
June 10, 1872	40,000 00
March 3, 1873	30,000 00
June 23, 1874	20,000 00
March 3, 1875	15,000 00
August 14, 1876	10,000 00

The original estimate made in 1871 for improving this harbor provided for an expenditure of $196,000, to be devoted to the construction of a breakwater, and to dredging a channel 200 feet wide and 14 feet deep at mean low-water. A riprap breakwater was commenced with the appropriation for 1871, and continued the following year. It was carried to a length of 1,380 feet.

Subsequent appropriations were applied to dredging, first making the channel 300 feet wide and 9 feet deep at low water; afterward increasing the depth to 12 feet over a channel 100 feet wide.

Bridgeport is the port of entry of the Fairfield collection-district. The amount of revenue collected at Bridgeport for the fiscal year ending June 30, 1877, was as follows:

For duties on imports	$1,248 54
For tonnage tax	82 50
For marine-hospital tax	1,635 12
Total	2,966 16

Number of foreign vessels arrived from foreign ports	18
Number of foreign vessels cleared for foreign ports	19
Number of American vessels arrived from foreign ports	2
Number of American vessels cleared for foreign ports	None.
Total arrivals	20
Total cleared	19

The following approximate statement of the arrivals and departures has been received from the collector of the port:

		Tonnage.
Steamers	750	559,194
Brigs	8	1,424
Schooners	700	87,500
Sloops	525	10,500
Barges	75	13,125
Canal-boats	500	75,000
Total arrivals	2,558	746,743
Total departures	2,558	746,743
Arrivals and departures	5,116	1,493,486

Money statement.

July 1, 1876, amount available	$54 85
Amount appropriated by act approved August 14, 1876	10,000 00
	10,054 85
July 1, 1877, amount expended during fiscal year	167 90
July 1, 1877, amount available	9,886 95
Amount (estimated) required for completion of existing project	40,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	20,000 00

C 7.

SOUTHPORT HARBOR, CONNECTICUT.

By act of Congress approved August 14, 1876, $5,000 was appropriated for the improvement of the harbor at Southport, Conn.

It is proposed to expend this money in repairing the breakwater at a few points where disintegration of the old wall has occurred, to repair the walls of the dike, and fill the space between them where the material has been washed out. This can be done by days' labor to better advantage than by contract.

Southport Harbor is in the Fairfield district, of which Bridgeport is the port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1877, was $2,966.16.

The following sums have been appropriated for this harbor since 1838:

March 3, 1875	$5,000 00
August 14, 1876	5,000 00

The only estimates made for improving this harbor since the work done in 1838 have been for repairs upon the breakwater and dike and for increasing the channel depth from 2 feet to 4 feet at mean low-water.

The repairs will be completed with the money already appropriated; $80,000 being still required for dredging. This sum could be profitably expended during one working season.

COMMERCIAL STATISTICS.

The following statistics have been received from Mr. John H. Perry, under date of July 28, 1877:

There are 11 sailing-vessels and one steam-tug owned either in whole or in part in this place. Of the sailing-vessels, from 2 to 4 run weekly, carrying freight to and from New York. The others are engaged in the coasting-trade.

Our vessels range from 7 feet 8 inches to 11 feet draught, and register an average of 150 tons burden. The cargoes of our regular weekly boats average $1,500 each trip. About 3,500 tons of coal are brought here annually, besides brick, lumber, and manure.

Owing to its poor channel and the absence of a light, our harbor has been used but little as a harbor of refuge. It remains open in winter when all others from New York to New London are closed, and, with good facilities for transportation, there is no reason why we should not become a thriving manufacturing village.

Money statement.

July 1, 1876, amount available	$383 99
Amount appropriated by act approved August 14, 1876	5,000 00
	5,383 99
July 1, 1877, amount expended during fiscal year	320 06
July 1, 1877, amount available	5,063 93
Amount (estimated) required for completion of existing project	8,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	8,000 00

C 8.

NORWALK RIVER, CONNECTICUT.

No work was done on the improvement of the river during the fiscal year ending June 30, 1877, and no appropriation made since the act of Congress approved March 3, 1875.

In my last annual report an estimate was presented for completing the improvement at an expenditure of about $30,000. I would respectfully renew the recommendation then made that this sum be appropriated to complete the work.

Norwalk is in the Fairfield collection-district, and Bridgeport is the nearest port of entry. The amount of revenue collected there during the fiscal year ending June 30, 1877, was $2,966.16.

The following appropriations have been made for this harbor:

June 10, 1872	$10,000
March 3, 1873	10,000
June 23, 1874	10,000
March 3, 1875	7,000

An estimate of $34,000 was made in 1871 for completing a channel 100 feet wide and 6 feet deep at mean low-water, at 20 cents per cubic yard.

The cost of doing this work proving considerably greater than was estimated, the desired channel has not yet been attained. As was exhibited in the last annual report, an additional sum of $30,000 will be needed to carry out the original project; of this sum, $15,000 could be advantageously expended during the ensuing fiscal year.

Money statement.

July 1, 1876, amount available	$190 62
July 1, 1877, amount expended during fiscal year	190 62
Amount (estimated) required for completion of existing project	30,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	15,000 00

C 9.

PORT JEFFERSON HARBOR, LONG ISLAND, NEW YORK.

At the close of the last fiscal year, work on the west jetty was in progress, the contractor, Mr. F. H. Smith, having placed in the work 3,192 tons of stone. His contract was extended 10 days, in which time 741 tons of riprap were added, exhausting the allotment for the work, and carrying the structure to a length of 475 feet, and height of 4 feet above mean high-water. This jetty was well built, and has proved its value in arresting a large amount of sand and gravel upon its western side, and also in the effect of confining the tidal currents, by which the middle ground has been nearly removed. As recommended in my last annual report, this jetty should be extended about 600 feet farther; when this is done, and the eastern jetty carried out correspondingly, it is believed that a satisfactory depth of channel over this bar, when once obtained, will be self-sustaining.

An appropriation of $6,000 for the improvement of this harbor was made by act of Congress approved August 14, 1876, but authority to expend the same was suspended by direction of the Secretary of War until the present season. In March, 1877, I made a careful examination of the harbor, submitting a report and project with regard to repairing and extending the east jetty, which was approved. In accordance with this project proposals were invited for doing the work.

The bids were opened on the 24th of May, 1877, and the contract subsequently awarded to Messrs. Ingerson and Molthorp, the lowest bidders, at $1.33 per ton of granite placed in the work.

It is also proposed, during the season, to make a cutting across the bar, perhaps 50 feet in width, with a view to ascertain definitely the character of the material of which the bar is formed, the difficulties to be encountered from the force of the tidal currents, and the stability of the opening, now that the jetties are so well advanced as to afford protection.

No dredging has ever been done on this bar, but a contract was last year made with Mr. Sidney F. Shelbourne to excavate a channel there, at 27 cents per cubic yard.

Although repeatedly urged to begin the work in the summer of 1875 and the following spring, the contractor signally failed to accomplish more than an attempt, removing but a partial scow-load, and then abandoning the work altogether.

I have previously reported upon the desirability of completing these improvements at an early day.

The great capacity of this harbor, and its complete shelter, render it exceedingly available as a harbor of refuge for the south side of Long Island Sound, and it needs but the appropriation of a moderate sum, in addition to that already expended, to open the entrance so that access may be had by all vessels requiring its protection.

The surveyor of the port reports that—

> There are about 170 vessels belonging to this port, all of which visit here an average of three times a year; their aggregate tonnage amounts to nearly 16,000 tons.
>
> During the year ending June 30, 1877, there were built here 7 vessels, with a total tonnage of 1,757 tons, and there are now 5 vessels upon the stocks, whose tonnage will aggregate 1,300 or 1,400 tons.

The following estimates are presented for completing the works, and are rather lower than those previously made, owing to reduced prices for labor and material:

Extension of east breakwater to 9-foot curve, 8,000 tons of riprap, at $1.50 per ton	$12,000 00
Extension of west breakwater 600 feet, 7,000 tons riprap, at $1.50 per ton	10,500 00
Dredging channel 100 feet wide and 8 feet deep, requiring excavation of 25,000 cubic yards, at 30 cents	7,500 00
Contingencies and supervision	4,000 00
Total	34,000 00

Of this sum $20,000 could be profitably expended during the next fiscal year.

The following amounts have been appropriated for this harbor:

March 3, 1871	$15,000 00
June 10, 1872	15,000 00
March 3, 1875	15,000 00
August 14, 1876	6,000 00

The original plans, proposed by General Warren in 1871, contemplated the construction of a far more elaborate breakwater at the east side of the harbor than has been built. This work was designed to contain over 10,000 cubic yards of stone, including a top wall of dimension stone, and was estimated to cost $150,000. The work has been commenced upon a much cheaper plan, viz, rough riprap of triangular cross-section. By using care in placing the stones compactly, it is hoped that a breakwater built in this manner will answer the purposes intended as well as the more costly structure at first contemplated.

Money statement.

July 1, 1876, amount available	$11,006 23
Amount appropriated by act approved August 14, 1876	6,000 00
	17,006 23
July 1, 1877, amount expended during fiscal year	5,744 59
July 1, 1877, amount available	11,261 64
Amount (estimated) required for completion of existing project	34,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	20,000 00

PROJECT FOR REPAIRING AND EXTENDING THE EAST JETTY.

ENGINEER OFFICE, UNITED STATES ARMY,
New London, Conn., March 31, 1877.

GENERAL: I have the honor to transmit the following report and recommendations with regard to the harbor of Port Jefferson, Long Island, as the result of a recent examination of the works designed to improve the channel over the bar at the mouth of the harbor.

The jetty constructed at the east side of the entrance in 1872 and 1873, for the purpose of arresting the movement of sand and gravel along the beach from Mount Misery, does not yet entirely fulfill the object for which it was intended. Its length was 1,050 feet; less than 700 feet are now visible, the remainder having been buried in sand.

Although a vast quantity of material has been arrested and retained in the vicinity of the jetty, a large proportion has gone to the west side. This is because the jetty was not extended far enough seaward, was not sufficiently compact, and was not built high enough, particularly at the shore end. These defects were doubtless owing to the limited amount of money applicable to the work, the endeavor being to cover as much space as possible, and effect the most good with the means at hand.

Owing to the present inadequate condition of this jetty, the proportion of material deposited to the west side or beyond it, where it is desired to make the channel, is greater than that arrested on the east side. Any increase of depth over the bar can

be permanent only when the deposit of gravel, sand, and stones west of this jetty shall have been prevented.

My recent examination confirms what previous observation led me to believe, viz, that this material finds its way from Mount Misery around the end of the jetty through its interstices and over its shore end. Between 300 and 400 linear feet of the original structure have become buried by the accumulations of sand, &c., and during the concurrence of high tides and northeast storms large quantities of material are carried over this newly-made beach and dropped in the channel beyond. The stones of the work have perhaps been undermined and settled; at all events, this part of the jetty is so low that it does not afford the necessary obstacle to the passage of sand and gravel under the conditions above mentioned.

To remedy this defect, a post and plank fence 200 feet in length was constructed in the fall of 1875. Storms have since demolished about one-half of it; the remainder, in good condition, is banked with sand and will probably remain.

The space between the breakwater and this fence should be occupied by a stone wall of medium size riprap, and a continuation of the fence carried up to the crest of the beach.

The breakwater at its shore end should be raised, and the whole length chinked with small riprap to prevent, as nearly as possible, the passage of sand and gravel through it. The length of the breakwater seaward should also be increased some 400 feet to the 9-foot curve, in accordance with the original design.

The west side jetty, built last year, has already arrested a large quantity of material west of its position, and has so modified the direction of the current as to cause the almost entire removal of the middle ground, which was heretofore a dangerous obstruction.

The bar itself, or ledge, as it is technically called, has been but little affected, owing to the heavy nature of the material of which it is composed.

I inclose herewith a tracing showing plan of the harbor's entrance, as it appeared at the close of work in July, 1876. Upon its margin I have drawn an approximate section upon the line of the east jetty, at its shore end, to exhibit the present condition at that place.

In view of the importance of preserving the channel from further deterioration by the accumulation of material west of the east jetty, I urgently recommend that the appropriation made last year for this work, together with the balance remaining from a previous appropriation, be immediately applied, and that an additional sum of $20,000 be asked for.

These amounts should be applied, first to the thorough repair of the east jetty, and a small sum should be expended in breaking a narrow passage through the "ledge," to enable the current to take hold of the loosened material and scour out a channel that may prove of sufficient magnitude to require no further dredging.

I am, general, very respectfully, your obedient servant,

J. W. Barlow,
Major of Engineers, U. S. A.

Brig. Gen. A. A. Humphreys,
Chief of Engineers U. S. A.

APPENDIX D.

ANNUAL REPORT UPON THE WORKS IN CHARGE OF LIEUTENANT-COLONEL JOHN NEWTON, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1877. BY CAPTAIN JAMES MERCUR, CORPS OF ENGINEERS, TEMPORARILY IN CHARGE.

UNITED STATES ENGINEER OFFICE,
New York, July 14, 1877.

GENERAL: I have the honor to transmit herewith the annual reports upon the river and harbor works temporarily under my charge, for the fiscal year ending June 30, 1877.

Very respectfully, your obedient servant,

JAMES MERCUR,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A.

D 1.

IMPROVING HUDSON RIVER, NEW YORK.

Lieut. J. H. Willard, Corps of Engineers, stationed at Albany, N. Y., has remained in superintendence of these works.

The following extracts made from his report will give a correct idea of the work done during the year:

SURVEYS.

The last fiscal year closed with the survey from Port Schuyler to Bath. July 8 a resurvey was made on the Overslaugh to test the work of dredging, in May and June, 1876. July 20 a survey was made from the State Dam at Troy to Cheney's Dock. The party was then reduced, and no more work was done in the field till November. November 3 to 9 resurveys were made to New Baltimore, the Overslaugh, and the new channel below the dam, when the season closed.

I commenced work this spring much earlier than usual on account of the quiet breaking up and the slight freshets. A reconnaissance was made in March, and April 3 a party was organized and took the field under Mr. R. H. Talcott. We have surveyed and platted the river from New Baltimore to Cedar Hill, from Van Wies Point to Cuyler's Bar, and from Port Schuyler to Bath. Re-examinations are now making at New Baltimore and Mull's Cross-over, where dredging has been going on.

The surveys embraced the district of shoal-water at New Baltimore, Coeyman's, Mull's, Castleton, Cedar Hill, Van Wies, Lower Overslaugh, Old State Wing-dam, Upper Overslaugh, Cuyler's Bar, Bath, Kellogg's Shoal, Fish-house Shoals, Round Shoals, Covell's Folly, Van Buren's and Washington Bars. Special examinations were made of rocks at New Baltimore and in the West Channel at Mull's. Work during the present season will consist of triangulation and filling in with plane-table, in examinations of the districts dredged by the State, in borings for rock, and in assisting in preparing the maps for the commission on pier and bulkhead lines.

The amount of work is summarized as follows:

	July 1 to November 9, 1876.	April 3 to June 30, 1877.	Total.
Length of river surveyed ....miles..	$2\frac{1}{3}$	$17\frac{1}{2}$	$19\frac{5}{6}$
Length of lines of soundings ....miles..	$14\frac{1}{4}$	$133\frac{1}{3}$	$147\frac{7}{12}$
Number of lines of soundings	121	713	834
Number of soundings	2,007	10,958	12,965

The expenditures on account of surveys to June 30, were: Salaries and wages, $5,921.32; steam hire and transportation, $415.50; expenses of tide-gauges, $159.29. Total, $6,496.11.

For examination of Mud Shoal, Jersey City, charged to this appropriation, $249.87.

The estimate for the years 1878–1879 is $8,000.

NEW WORK.

Owing to the state of the appropriation no work was undertaken till late in the fall of 1876. Proposals for about 3,000 feet of full-dike were received October 18, and the long-projected dike on the Overslaugh was commenced October 31. One thousand feet were finished, accepted, and a partial payment of 75 per cent. was made December 14, 1876.

A cross-dike 424 feet long, to connect the new work with the east shore, was built by day's labor, and cost, including stone filling, $969.90. One thousand two hundred and twenty feet of half-dike were built by day's labor on the line of the full-dike and partly filled with stone, when the river suddenly closed and prevented further work. The cost of this work was $1,741.02.

This work was injured very much during the winter and in the springs floods; the river froze over at a low stage and the ice worked on piles which had not been protected by stone, pulling them up and breaking them away from the horizontal timbers. I secured what I could before the ice went out, and found some of the piles and timber after the freshet had gone down. The work is now being restored and filled with stone.

Work was resumed on the full-dike May 23; 1,600 feet of timber work has been finished and delivery of stone begun. The contract has been extended, and I expect to have the work finished before August.

Contract work for the present season should include 830 feet of dike at Bath, above Albany, to close the gap between Bath and Base Island dikes. This was contemplated last season, but the state of the appropriation would not permit. The estimate has been reduced to $4.00 the running foot. The new dike on the Overslaugh forms part of a system of dikes, the plan of which was submitted to General Newton last year and approved by him.

A new section, beginning about half a mile below the south end of the present work, should be built at about the same distance, 750 feet, from the dikes on the west shore. This work should be about 3,000 feet long, and should cross the old wing-dam from the east shore. A cross-dike 700 feet, to connect with the east shore, should be built on the line of the wing-dam, that being the line of cheapest construction. The estimate for the full-dike is $3.75 the foot, and for the cross-dike $1.50 the foot.

General Newton proposed building a spur-dike at New Baltimore to direct the ebb-current into the west channel, but as the State is now dredging on that line I think it would be good policy to delay building till the working of the new channel can be observed.

Since my last report I have given a good deal of study to the maps of 1819, 1831, 1838, 1843, and of recent date. They all unite to confirm the opinion that the channel from New Baltimore to 9-mile tree should be along the west shore.

To secure this, however, it will be necessary to remove Austin's Rock, the rocks at Mull's, and at New Baltimore. The rock is limestone, divided by veins of slate. Lieutenant Willard estimates the total cost of removal at $6 per cubic yard.

REPAIRS.

All the dikes at Coeymans were injured during the winter of 1875–'76, and other works suffered to a greater or less degree. In some cases timber was torn away or broken down and piles pulled up, and in all the filling had sunk one or two feet. Bids were invited for labor and materials, and for 2 000 cubic yards of quarry-stone delivered in the dikes. The stone was furnished at 63 cents per yard, and was used in leveling the Coeymans middle-ground dike and in filling the new half-dike and cross-dike on the Overslaugh. The works repaired were the New Baltimore west dike, north end, Coeymans middle dike, Bath and Patroon's dikes, and a small amount spent in beginning the opening in Port Schuyler dike. New bids were asked for stone in May, and the lowest offer, 53 cents per cubic yard delivered, was accepted. Stone has been put into the small island dike, the Overslaugh half-dike, and the cross-dike, and will be put into the dikes at Douw's Point and Van Wies. A small amount will have to be devoted to repair of dikes at Bath, Douw's, Van Wie's, Parda Hook, Coeymans, and New Baltimore. These works were injured by the ice, which formed so quickly while the river was at a very low stage that it got a firm hold of piles and timber and raised the dikes bodily. The piles will have to be driven down and extra piles driven

along the face to secure those dikes which are in danger of being undermined. Eight hundred dollars is estimated for the work of repair and $600 for filling.

The amount expended last year, including stone, was $810.96. An estimate of $2,000 is made for 1878 and 1879.

STATE WORK.

In May, 1876, the State legislature granted $40,000 for assisting the work of improving the Hudson, the amount to be expended under the direction of the State engineer. An agreement was made by which I undertook to furnish all maps and surveys that should be required, to recommend lines for dredging, and to assist in locating machines, &c., and Mr. Van Buren was to charge himself with the business of contracts. A large amount of valuable work was done in this way, and the general appropriation was left unincumbered for construction of permanent works.

The bars removed or reduced were—

	Cubic yards.
1. New channel at Sloop-lock, Troy	27,866
2. Van Buren, Port Schuyler	11,934
3. Washington Bar, Port Schuyler	12,401
4. Fish-house Shoal	11,355
Amount between Albany and Troy	63,556
5. Upper railroad-bridge, Albany	1,743
6. Upper Overslaugh	48,687
7. Part of west wing-dam	6,197
8. East channel, New Baltimore	9,907
9. West channel, New Baltimore	6,619
Amount below Albany	73,153
Total amount	136,709

Gross cost $26,919.94, or about 20 cents per cubic yard, measured in the scows.

From examination of the map, and from borings made under my personal direction, it was decided to cut a new channel to the sloop-lock at Troy, passing through islands west of the usual route, which is obstructed by rock. The work was finished in October, 1876, and gives a channel 60 feet wide and 7½ feet deep at low-water, which is sufficient for all boats of the river and canal on the "northern line." A balance of $13,080.06 remained for use this spring, and $15,000 additional was granted by the legislature this year, to be expended as before. With $28,080.06 on hand, and with the most important surveys finished, Mr. Van Buren was able to begin work in May.

Contracts have been let for removing 70,000 yards from the west channel at New Baltimore, at 10 cents the cubic yard; 60,000 yards from the east channel at Mull's, at 10¾ cents the cubic yard; and 60,000 yards, including the wing-dam on the Overslaugh, at the same rate. The rate accepted for work above Albany is 12 cents the cubic yard, measured in scow, but the quantities have not yet been determined.

I was much opposed to the plan of opening the east channel at Mull's, being convinced that the relief would not be permanent. Both Mr. Van Buren and his deputy, Mr. D. M. Greene, were of the same opinion, but did not feel warranted in attempting rock-excavation with so small a balance available. They will join us in the fall in making a beginning on some of the most dangerous points of the reef; and if these are removed, the channel will be available for tugs and some of the small steamboats that run between Albany and the cities below.

I hope to persuade the State engineer to cut off the projecting bar below the Middle Ground dike at Coeymans. At present this bar forms an obstacle to the flood-tide and makes a crossover. Removal of 25,000 cubic yards will materially benefit the channel at this point, making the course straight and easy of navigation.

I must say here, that if it had not been for the money spent by the State engineer, navigation of this part of the Hudson would have been seriously impaired. The general appropriation had become almost exhausted; no funds were granted till the end of the long session, and they were not available until the middle of autumn. The obstructions were caused by ice-gorges, and must be classed among casualties against which it is impossible now to provide. When all rocks and other obstructions shall have been removed, and the river thus materially deepened, there will be little to be feared from ice-gorges.

DREDGING.

I expended $285 in dredging on the crossover above the Overslaugh before the State appropriation became available, paying the price afterward agreed upon in the contract made by the State engineer. This work was a matter of pressing necessity. The amount was 1,900 cubic yards, which I expected would be paid for by the State, but it was undertaken before the State money was appropriated.

BULKHEAD LINES.

In order to carry out the suggestions in the last report, looking to the establishment of pier and bulkhead lines on the Hudson from Troy to deep water, a concurrent resolution was passed by the State legislature in April, and, at the Governor's request, the President has appointed a board of United States officers, to be associated with certain officers of the State government, to fix the lines.

PROTECTION OF DIKES.

The dikes between Albany and Troy have suffered a good deal from river-thieves. The high dike below Hill-house Island has lost about 200 ties, and timber has been freely taken from the old crib-dike above Base Island. The depredations are committed in the winter, and probably at night, and the work is done by men who have tools, for the timber is sawed out, and generally without disturbing the face of the work. I have made complaints, both by letter and in person, at Albany, Troy, and West Troy but have not been able to discover the thieves or to prevent the plundering.

This work is in the fourteenth collection-district, Albany being the port of entry.

The value of imports for the fiscal year was $495,905, gold.

The amount of revenue collected on same was $102,236.92.

The tonnage of the port is 268 vessels; 42,162.54 tons.

The amount of commerce and navigation benefited is estimated at five hundred millions dollars.

Amount asked to be appropriated for fiscal year ending June 30, 1879, removal of Austin's Mills, and New Baltimore Rocks	$84,000 00
Construction of dikes at Shad and Schermerhorn Island	24,000 00
Completion of Overslaugh system	12,000 00
Renewal and raising dikes at Base Island	6,000 00
	126,000 00
Amount of estimate of 1868	984,304 47

AMOUNTS APPROPRIATED.

By act of Congress approved June 23, 1866	$50,000 00
By act of Congress approved March 2, 1867	305,188 00
By act of Congress approved July 25, 1868	85,000 00
By act of Congress approved April 10, 1869	90,000 00
By act of Congress approved July 11, 1870	40,000 00
By act of Congress approved March 3, 1871	40,000 00
By act of Congress approved June 10, 1872	40,000 00
By act of Congress approved March 3, 1873	40,000 00
By act of Congress approved June 23, 1874	40,000 00
By act of Congress approved March 3, 1875	40,000 00
By act of Congress approved August 14, 1876	50,000 00
Total	820,188 00
Amount expended	783,327 58

Money statement.

July 1, 1876, amount available	$5,515 09	
Amount appropriated by act approved August 14, 1876	50,000 00	
		$55,515 09
July 1, 1877, amount expended during fiscal year	18,654 67	
July 1, 1877, outstanding liabilities	9,876 00	
		28,530 67
July 1, 1877, amount available		26,984 42
Amount (estimated) required for completion of existing project		164,116 47
Amount that can be profitably expended in fiscal year ending June 30, 1879.		126,000 00

Abstract of bids for constructing full dike on Overslaugh, October 18, 1876.

Bidders.	Rate per foot.
E. H. French	$5 25
James D. Leary	5 00
George W. White	4 89
H. V. Sloat & Bro	4 73
P. Sandford Ross	4 70
J. Walsh	4 49
Stephen Miles	4 44
J. F. Ward	3 95
J. H. Marshall	3 79
William D Fuller	3 48

Abstract of contract for constructing dike on Overslaugh, Hudson River.

Contractor.	Residence.	Date of contract.	Subject of contract.	Remarks.
William D. Fuller	Albany, N.Y.	Oct. 26, 1876	3,000 feet pile dike, more or less	To be completed July 31, 1877.

D 2.

REMOVING OBSTRUCTIONS IN EAST RIVER AND HELL GATE, NEW YORK.

HALLET'S POINT.

This work was under the superintendence of Capt. W. H. Heuer, Corps of Engineers, assistant to Lieutenant-Colonel Newton until the 20th of July, 1876. Capt. James Mercur, Corps of Engineers, having reported for duty in compliance with orders from the War Department, was on the 5th of August assigned by Lieutenant-Colonel Newton to duty as superintendent.

At the beginning of the fiscal year the excavation at Hallet's Point was complete and the necessary holes for receiving the final charges had been drilled.

Agreements for furnishing the necessary explosives, &c., having been made, the work preparatory for the final blast was commenced on August 6, and was carried forward from that time until September 24, at which date the blast was successfully fired.

A preliminary report upon this work has already been rendered by Lieutenant-Colonel Newton, and a detailed report of the entire progress of the work from its inception is now in course of preparation under his supervision, and will be submitted as soon as completed.

After the blast, a contract for removing 24,000 tons of broken rock, at $2.40 per ton, was made with Mr. Emory R. Seward, who is now at work in accordance with the terms of the contract. At the beginning of the dredging he experienced numerous delays arising from unfamiliarity with work of this kind, the breaking of machinery, collisions with sailing-vessels, and the heavy ice running during the winter; but, profiting by experience gained, he is now making good progress in the work.

The total amount of rock to be removed in order to secure a minimum depth of 26 feet at mean low-water is about 75,000 tons, or 37,500 cubic yards.

Up to the end of the fiscal year there has been removed 14,055.61 tons.

The result of the dredging shows the whole rock to be thoroughly broken up.

FLOOD ROCK.

The end of the last fiscal year left the excavation at Flood Rock filled with water, the pumps and drilling machines having been removed and all work stopped in May, 1876.

Work was recommenced here on September 30: the water having been pumped out, the drills were started upon October 7. The excavation was carried forward from this time, working three shifts of eight hours each daily until December 31, when the heavy ice running in the river rendered it impracticable to continue regular work. The pumps and machinery were, therefore, removed from the mine, and it was allowed to fill with water. Considerable difficulty was experienced in obtaining fresh water for the boilers toward the last of December, owing to the freezing of the water in the lead pipe leading to the rock from the shore. One day's work was lost owing to an extraordinary high tide occurring, with high wind, which caused a large quantity of water to flow into the mine through the shaft; an entire day was required to pump this out far enough to continue work.

The following is a statement of work done between October 7 and December 31, 1876:

Number of feet of holes drilled	13,311
Number of holes blasted	3,303
Number of drills sharpened	1,777
Loss of steel by abrasion, pounds	178
Number of cubic yards of rock removed	1,772.2
Average drilling per cubic yard, feet	7.51
Average explosive per cubic yard, pounds	2.08
Average cost per cubic yard	72.8c.
Total expenditure at Flood Rock during October, November, and December, including cost of steamboat, material for and building dock 40 feet long	$20,656.61

The rock removed was dumped in the shoal-water upon Flood Rock and the Gridiron, for the double purpose of covering the Gridiron, as an improvement to navigation, and of forming a sufficiently large area to contain the necessary shops and engine-houses for continuing the work at the rock. No appropriation having been made for removing the obstructions in the East River and Hell Gate for the fiscal year ending June 30, 1878, it became necessary to suspend all work at Flood Rock, except such as was absolutely necessary for the preservation and storage of materials.

The only work done after January 1 consisted in overhauling and storing the machinery, rebuilding a portion of the sea-wall torn down by ice, moving the laboratory and water-tanks, whose foundations were washing away owing to insufficient protection, and taking up the tracks for dump-cars for similar reasons.

As soon as this work was accomplished, the employés were discharged and the works left under charge of a watchman. One surface-blast was made for removing a projecting point of the scaly rocks; sixteen pounds of Vulcan powder were used.

STEAM-DRILLING SCOW.

The following extracts from the report of Mr. J. H. Striedinger, assistant engineer in charge of the steam-drilling scow, will give sufficiently

full information of the work performed by this machine during the fiscal year ending June 30, 1877.

CAPTAIN: I have the honor to report upon the operations of the United States steam-drilling scow during the fiscal year ending June 30, 1877, as follows:

From July 1 to September 28, 1876, the crew of the scow was employed in assisting at the preparations for and the examination after the destruction of the reef at Hallet's Point, Hell Gate, New York.

On October 19, 1876, she was towed from Greenpoint, L. I., to Diamond Reef, East River, and rock removal was again vigorously begun.

It was on this occasion that we anchored the scow over the reef in one hour and fifteen minutes, the quickest time on our record.

The center-anchors being placed from the very beginning exactly where buoyed out by me, no change of anchors was required during the whole season.

Instead of nitro-glycerine, Vulcan powder, a kind of lithofracteur, was experimentally used for charging the drill-holes this time.

The filling of the tin cartridge-shells was done at the Vulcan Powder Factory, about 4,000 yards distant from Diamond Reef. By simultaneously detonating the charges of adjacent drill-holes, the maximum of the explosive effect was always secured.

The greatest number of holes thus fired was 21, with a charge of 1,614¼ pounds of Vulcan powder, and the largest amount of this American lithofracteur used in one blast was 1,728½ pounds.

The closeness of the Governor's Island and the New York City shores, 500 yards distant from the reef, appears to limit the maximum size of charge, which can be simultaneously detonated without hurtful effect upon the nearest structures to about 2,000 pounds of this high explosive when distributed in only 26 drill-holes, 7 feet apart, drilled in the direction of the line of least resistance, and tamped by 18 feet of water. Messrs. Morris & Cumings's dredge, in charge of Captain Wilson, was placed over the reef on December 4, 1876, and continued removing the rock broken up by the blast until the operations were suspended. The time from the middle of December to the cessation of operations, December 23, 1876, was mostly employed in thoroughly surveying the reef by means of our sounding apparatus, and in assisting the raising and disposing of unwieldy *débris*. To this end bowlders and large stones exceeding 9 tons in weight were "basket-chained" by our divers, then raised by the dredge and placed on the stone scows.

On December 18, 1876, a bowlder estimated to weigh 50 tons was in this manner secured to the dredge's chains, and after three futile attempts to lift it about the water's surface the dredge with this stone held in suspension was moved down stream, and having reached a point off the reef indicating a depth of 38¼ feet at mean low-water, the big stone was lowered on the river's bottom. The soundings taken by our divers on the highest points of the bowlder giving a minimum depth of 27¼ feet at average low-water, the chains were unshackled and the dredge brought back again to the reef. Two collisions happened while anchored over Diamond Reef. By the more serious one the blacksmith-shop was slightly damaged.

The dome was lowered sixteen times for drilling purposes.

The following is a resumé of last fall's drilling, blasting, and dredging operations:

Total number of holes drilled	185
Total number of feet drilled	1,997.8
Total amount of Vulcan powder used in 16 drill-hole blasts, pounds	14,244
Cubic yards of *débris* removed	916.25
Total time of dredging	13 days, 7 hours, 37 minutes.
Average number of feet drilled by each machine per eight-hour shift	9.98
Average depth of hole, feet	10.8
Average cost of linear foot of hole drilled, including towing scow to reef; running anchors of scow; moving scow near position of drilling; examining position; placing scow over it; lowering dome, locating and placing drills; plotting sextant observations; expenses of drilling; cost of sharpening drills; expenditure of steel; taking out the drills and plugging the holes; hooking on to dome, and hoisting it up after drilling operations; heaving off scow	$3 07
Average cost of sharpening a drill	$1 41
Average number of feet drilled to each sharpening	10.0
Expenditure of steel to each foot of hole drilled, ounces	2.88
Average cost of dredging and dumping one cubic yard of *débris*	$2 97

The removal of the *debris* not being completed, the items referring to the "amount of explosive used per cubic yard," and the "total cost of removing one cubic yard of bed-rock," &c., had to be omitted for the present.

The very low figure for dredging thus far is due to the presence of the large craters of broken stone which the grapple met with at the very beginning. The cost per cubic yard for the further removal of these *debris* will, therefore, considerably increase

before the 26-foot mean low-water curve is reached. During the months of March and April, 1877, the scow's tender, the United States steam-tug Star, was thoroughly repaired, and the scow herself provided with a new boiler and two additional water-tanks.

Owing to the lack of funds, last year's appropriation being nearly exhausted and no new one having been granted thus far, no submarine drilling and blasting or dredging operations could be recommenced this spring.

I should not conclude this report without acknowledging the able co-operation I again enjoyed by Messrs. James R. F. Kelly, Kelles Karrow, T. Conklin, R. Rodgers, J. S. Downs, and A. Nolting during the work on Diamond Reef.

This work is in the collection-district of New York.

The nearest port of entry is New York City. The amount of revenue collected last fiscal year was $102,352,037.65.

The amount of commerce and navigation benefited by the completion of this work would be about $4,000,000 daily.

Amount asked to be appropriated for fiscal year ending June 30, 1879:

Work of steam-drilling scow on Diamond Reef, Frying Pan, and Shelldrake	$150,000 00
Excavations at Flood Rock, (middle reef)	450,000 00
	600,000 00

ORIGINAL ESTIMATE.

Removing reefs at Hell Gate and Diamond and Coenties Reefs	$5,139,120 00

Amounts appropriated—			
By act of Congress approved July 25, 1868		$85,000 00	
By act of Congress approved April 10, 1869		180,000 00	
By act of Congress approved July 11, 1870		250,000 00	
By act of Congress approved March 3, 1871		250,000 00	
By act of Congress approved June 10, 1872		225,000 00	
By act of Congress approved March 3, 1873		225,000 00	
By act of Congress approved June 23, 1874		225,000 00	
By act of Congress approved March 3, 1875		250,000 00	
By act of Congress approved August 14, 1876		250,000 00	
		1,940,000 00	
Deduct amount reverted to United States Treasury	$3,158 55		
Deduct amount allotted to Harlem River	11,000 00		
		14,158 55	
			$1,925,841 45
Amount received from other sources			151 00
			1,925,992 45
Amount expended			1,802,636 67

Amount expended during year ended June 30, 1877:	
Removing reef at Hallet's Point	$102,415 56
Excavations at Flood Rock	31,799 78
Steam-drilling scow	37,144 80
Contingencies, engineering, &c	9,576 54
	180,936 68

Money statement.

July 1, 1876, amount available	$54,141 46	
Amounts received from other sources	151 00	
Amount appropriated by act approved August 14, 1876	250,000 00	
		$304,292 46
July 1, 1877, amount expended during fiscal year	180,936 68	
July 1, 1877, outstanding liabilities	3,373 34	
		184,310 02
July 1, 1877, amount available		119,982 44
Amount (estimated) required for completion of existing project		3,213,127 55
Amount that can be profitably expended in fiscal year ending June 30, 1879		600,000 00

Abstracts of bids for removing broken rock from Hallet's Point Reef, Astoria, New York. Opened October 18, 1876.

Bidders.	Price per ton.
Morris & Cumings Dredging Company	$3 00
Atlantic Dredging Company	3 60
John A. Bouker	3 75
Emory R. Seward	2 40
George Conklin	7 00

Abstract of contract for removing broken rock from Hallet's Point Reef, Astoria, New York.

Contractor.	Residence.	Date of contract.	Subject of contract.	Remarks.
Emory R. Seward	Albany, N. Y.	Nov. 9, 1876	Removal of 24,000 tons of broken rock, more or less.	Contract to be completed by June 30, 1876, and extended to November 1, 1877.

DESTRUCTION OF REEF AT HALLET'S POINT.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., January 11, 1877.

SIR: Referring to my annual report for the last fiscal year, page 238, it will be seen that the officer in charge of the removal of obstructions from East River, New York, reported that the explosion at Hallet's Point (Hell Gate) would take place about September 15, 1876. It did not occur, however, until the 24th of that month, when the complete demolition of the reef was accomplished.

General Newton has made a preliminary report of the operations connected with the destruction of the reef, a copy of which is herewith submitted.

In view of the importance of the subject and the general public interest it has excited, I beg leave to suggest that the report be sent to the House of Representatives for the information of the Committee on Commerce.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brig. Gen. and Chief of Engineers.

HON. J. D. CAMERON,
Secretary of War.

LETTER OF LIEUT. COL. JOHN NEWTON, CORPS OF ENGINEERS, OF OCTOBER 5, 1877.

UNITED STATES ENGINEER OFFICE,
New York, October 5, 1877.

GENERAL: I return manuscript and printed preliminary report of explosion at Hallet's Point of December 16, 1876, corrected.

I also transmit a new manuscript appendix, which furnishes a complete solution of the explosion of mines by voltaic agency, which it is recommended to substitute for the printed appendix. This last is all

correct but is incomplete, going really no further than Abbot's general solution. If this substitution cannot be effected, I recommend the printing of the new paper as a separate article.

Very respectfully, your obedient servant,

JOHN NEWTON,
Lieut. Col. of Engineers, Bvt. Major-Gen., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

PRELIMINARY REPORT OF OPERATIONS CONNECTED WITH THE DESTRUCTION OF THE REEF AT HALLET'S POINT, EAST RIVER, NEW YORK.

UNITED STATES ENGINEER OFFICE,
New York, December 16, 1876.

GENERAL: This preliminary report of the operations at Hallet's Point, including the demolition of that reef on September 24, 1876, is respectfully presented.

For the detailed and complete report of these operations, the indulgence of the Department is asked until the facts and experiments recorded in this office can be collated.

The area operated upon, which included all that portion within the curve of 26 feet below mean low-water, was 3 acres. This space was perforated with 41 radial tunnels, long and short, and with 11 transverse galleries; leaving as supports to the roof 172 piers of the natural rock. The aggregate length of tunnels and galleries was 7,425.67 feet, and the amount of rock excavated from these and deposited in dump-piles on the land was 49,480 cubic yards.

The work of excavation was commenced in the latter part of October, 1869, and terminated in June, 1875; deducting the time lost by suspension of work, due to exhaustion of current appropriations, the actual period consumed in this work was four years and four months.

The appropriations were, under the law, devoted to many reefs in the East River and Hell Gate besides the one at Hallet's Point; the result being that work was rarely prosecuted in full force at the last-named place. With a more generous grant of money the time consumed until the explosion, which amounted in all to six years and ten months, could have been reduced to four years.

As soon as the excavation was finished, in June, 1875, the work of drilling holes in the roof and piers, to be afterward charged with explosives, was begun. At the completion, March 25, 1876, there had been drilled in the roof 5,375 3-inch, and in the piers 1,080 3 inch and 286 2-inch holes; the total length of holes drilled being 56,548 feet of 3-inch and 1,897 feet of 2-inch holes.

The execution of the foregoing work from July 5, 1870, to June 4, 1872, was under the personal superintendence of Mr. G. C. Reitheimer, now deceased. During his capable and efficient oversight the excavation was mainly effected through hand-drilling and the use of black powder.

The change to machine-drills and quick explosives was gradually effected by directions from this office; and from June, 1872, to June, 1875, the principal reliance was placed upon these.

Capt. Wm. H. Heuer, Corps of Engineers, had personal superintendence

of the works from June 4, 1872, until relieved from duty by orders dated July 20, 1876. Under his superintendence the larger amount of excavation was effected, and the tunnels and galleries completed. Incidentally, and under directions from this office, numerous trials were made of machine-drills, of the qualities of different steels for drilling purposes, and of the effects of different explosives. Captain Heuer's services were very valuable, his qualities as a faithful, efficient executive officer conspicuous, and his name cannot fail to be associated with the execution of the work.

The proximity of the reef to habitations at Astoria, Ward's Island, and Blackwell's Island made it necessary to devise a system of explosion which, effecting the work of demolition, would at the same time do no damage to life and property.

The atmosphere and the rock being the mediums through which the shock would be transmitted, it was essential that the waves propagated through these should be made as small as possible.

It was evident, in the first place, that, if to each charge its full capacity of useful work in the breaking up of the rock were assigned, regard being likewise had to the superincumbent weight of water, no external effect of moment would be perceived in the atmosphere.

In the second place, it was evident that the magnitude of the rock-wave would depend greatly upon the amount contained in individual charges; that is, if 80 pounds were required for the individual charge, the vibration of the rock would be much greater than if these charges did not exceed 20 pounds. It was known that 80-pound charges of nitro-glycerine, fired in numbers of 12 to 20, did not cause a *destructive wave*. Again, the reef, after excavation, being connected with the rest of the rock-formation only through the piers and the outer edge of the roof, it was inferred that the shock propagated in the rock should be estimated as due mainly to the charges necessary to disrupt the piers and roof from their connection with the bed-rock; and also that the additional number of charges required to break up the roof and piers would not enter largely into the amount of shock transmitted under ground.

These were the fundamental ideas upon which the system of mines was established. As the tunnels in radial lines concentrated upon the land, an accumulated explosive effect in that direction was prevented by so proportioning the charges that the roof should be broken through by the first impulse in many places, and thus give vent upward. To prevent a *concentric* explosion, by which the *débris* might be heaped up in large masses near the center of the area, the charges in the outer zone of the semi-elliptical reef were increased beyond those of the other portions, and by this means the masses of *débris* fell generally back in the places to which they originally belonged. Some portions were thrown beyond the limits of the reef toward the channel, and constituted what may be termed a *dispersive* explosion.

The mode of calculating and arranging the charges was to consider the roof-holes as the receptacles of explosives enough to form common mines.

The line of least resistance was assumed as the distance from mid-length of the charge to the surface of the rock. Since the charges were perfectly tamped by the confined water within the excavation, this rule of measuring the line of least resistance was assumed to be practically correct. With less perfect tamping, the lines of least resistance for such mines designed to break through the roof would have required estimates quite different.

The average amount of explosives required to break up and dislodge one cubic yard in enlargement had already been found to be 0.97 pounds, and from this resulted, $C =$ charge in pounds $= 0.038\ L^3$; L being line of least resistance in feet.

All roof-holes, excepting those over piers, were treated by this formula.

The piers, being very irregular in shape and size, would have exacted much care and time to have located the holes and proportioned the charges to the exact mathematical requirements in each case—one and a half pounds of explosive were assigned, as a rule, to each cubic yard of the piers—it being considered of the first importance to demolish completely these supports of the roof.

The roof-holes above piers were charged from formula $C = n\ L^3$; being successively 0.038, 0.05, and 0.06, increasing from the shaft outward.

The bodies of piers within the outer zone were charged with 2 pounds per cubic yard. Within the inner zone, where the depth was comparatively little, it was considered proper to reduce the charges to the smallest limit capable of affording a good result, both to avoid disturbance of the atmosphere and to prevent a concentrated action, due to the direction of the tunnels upon the land. The increased proportion given to the charges within the outer zone favored this intention, by giving quick vent to the gases in that direction.

The cubic contents of the roof and piers were 63,135 yards, and the amount of explosives as follows:

	Pounds.
Rend-rock	9,127¼
Vulcan-powder	11,852[illegible]
Dynamite	28,935¼
	49,915 9/16

Being at the rate of 0.79 pound to each cubic yard.

Rend-rock furnished by J. R. Rand & Co.:

Nitro-glycerine	33.4 parts by weight.
Charcoal	2.4 parts by weight.
Rosin	2.0 parts by weight.
Pulp, (paper or wood fiber)	2.7 parts by weight.
Sulphur	6.7 parts by weight.
Nitrate of potash	52.8 parts by weight.
	100

Vulcan-powder furnished by R. W. Warren:

Nitro-glycerine	30.0 parts by weight.
Charcoal	10.5 parts by weight.
Sulphur	7.0 parts by weight.
Nitrate of soda	52.5 parts by weight.
	100

Giant-powder No. 1, or dynamite, furnished by Atlantic Giant-Powder Company, Messrs. Varney & Doe, agents:

Nitro-glycerine	75.0 parts by weight.
Kieselguhr	25.0 parts by weight.
	100

The vulcan-powder was furnished at 26 cents, rend-rock at 27 cents, and dynamite at 60 cents per pound.

The first two, in quantities equal to the full amount charged, were considered quite sufficient to break up the rock, but as it was conjectural how long the cartridges, from outside interference, might have been

left exposed to wet, it was decided best to use a certain portion of dynamite, as being less liable to saturation by water.

Vulcan-powder, confined in a tin case left open at one end and exposed to still water until the contents became a mush, had been exploded by a fulminate cap, but the force of the explosion was diminished by such treatment.

The explosives were packed at the respective places of manufacture in tin cartridge-cases—the last being furnished by the Government.

The number of holes charged was 4,427 and the number of tins used was 13,596—87 per cent. being 22 inches and the remainder 11 inches in length.

The holes being tapering, the cases varied in diameter from $1\frac{3}{8}$ to $2\frac{1}{2}$ inches—the intermediate sizes differing by one-eighth of an inch.

One end of the tin case was fitted with a screw-cap with rubber washers, to exclude water, the other end being arranged with four short lengths of brass wire soldered on the perimeter of the bottom and spread out. When the cartridge was pushed home, the wires, by their elasticity, pressing against the side of the hole, prevented a falling out. This simple and effective device was due to Mr. Bernard Boyle, chief overseer of the work.

Several thousand of the dynamite cartridges, when delivered at the works, were, by some misapprehension, not screwed tight; and, as there was risk attending rectification of that defect, without taking precautions which would have consumed too much valuable time, it was decided to use them in the condition found; that is, liable to take in water.

On the 11th September, the charging of holes was commenced, and finished at 9 p. m. on the 20th, consuming nine days. Had the cartridges been delivered as agreed upon, this operation would have consumed only about four days.

After the holes had been charged with tin canisters, the next operation was to insert the priming charges, which were contained in brass tubes. Brass was preferred to tin on account of greater durability in salt-water and better protection against leakage—conditions insuring the detonators at least against moisture, should the exposure be of long duration.

The amount of these charges, $\frac{3}{4}$ of a pound to each primer, has been included in the grand total already given. The primers contained also, as detonators, fuses holding each 20 grains of fulminate of mercury. The terminals of two connecting wires were inserted in each fuse, and bridged with 0.0015 inch silver platinum wires $\frac{1}{4}$ inch in length. The fuses, in groups of 20, were connected in continuous series with connecting-wires. A lead and a return wire were attached to each group. The fuses, which were very perfect in quality, were furnished by J. R. Rand & Co., and manufactured under the immediate direction of Mr. H. Julius Smith, their electrician.

Twenty primers, with fuses and wires properly arranged in a box, with lead and return wires on reels, were carried to each party engaged in this work. The time consumed in placing 3,680 primers, unreeling the lead and return wires, and leading these out of the shaft, was two days and a fraction.

The connecting-wires, in lengths varying in the different groups from 20 to 35 feet, were copper wires of No. 18, American gauge, (0.04303 inch,) insulated by a coat of gutta-percha; the size, after coating, being No. 9, American gauge, (0.11443 inch.) The total amount used was 118,525 feet.

The lead and return wires were copper wires of No. 12, American gauge, (0.080808 inch,) insulated with two coats of gutta-percha; size of coating, No. 4, American gauge, (0.2043 inch.) The total amount used was 147,703 feet, in lengths from 250 to 625 feet.

The connecting and a portion of the lead wires were manufactured by S. Bishop; the remainder of the lead wires by Geo. M. Mowbray, of North Adams, Mass.

The charging of the holes with cartridges and primers was the critical part of the operation. To insure regularity and avoid confusion, the prolific source of accidents, contiguous holes, in groups of 20 each, were connected with plug-lines, and the spot marked out where the boxes containing the cartridges for a particular group should be placed. The numbers and sizes of the cartridges for each hole were known at the distributing depot of the cartridges, which was located in the shaft.

As fast as the holes were charged the plug-lines were restored to the original places, in order to guide the men intrusted with the primers, who were to go over the same ground.

It must be noted that the plug-lines represented, in reality, the connecting wires between the fuses, which were of uniform length in the same group, though varying in that dimension between different ones.

Owing to irregularity of delivery, there were at times as much as 15,000 pounds of explosives in the general depot, and precautions were redoubled until that amount was reduced within limits.

The batteries used consisted respectively of 40, 43, and 44 cells of zinc and carbon, or 960 cells in all, divided into 23 distinct batteries, each battery to fire 160 fuses, arranged in divided circuit in eight groups, of 20 each. The fluid was made in the proportion of 6 pounds of bichromate of potassa, 1 gallon concentrated pure English sulphuric acid, and 3 gallons of water. The formula by which the electrical apparatus, in its relation to the mines, was arranged and calculated, was the general formula for such batteries,

$$C=\frac{E}{R+r},$$

C being the current in webers; E the electromotive force; R the internal and r the external resistances.

Calling N the total number, and n the number of fuses in each group,

$$\frac{N}{n}=\text{number of groups.}$$

Then by the principle that the sum of the currents in the divided parts of a circuit is equal to the principal current,

$$C=\frac{N}{n}c=\frac{E}{R+r},$$

C being a maximum when $R=r$; c was a known quantity, determined by experiment, and representing the webers of current required to explode with absolute certainty n fuses of the kind in question. (See Appendix.)

In determining the constants for the wires, fuses, and batteries, Bradley's rheostat and galvanometer were the principal instruments employed.

Mr. J. H. Striedinger's services in these details, as also in those of the battery-frames and circuit-closer, were very valuable, and he likewise

developed much practical skill in laying down the wire system upon the ground without accident or interference with the other work going on.

Resistance of lead wire, per 100 feet	0.157 ohms.
Resistance of connecting wire, per 100 feet	0.68 "
Resistance of fuses, cold	1.90 "
Resistance of fuses at moment of explosion	2.01 "
Resistance of battery, per cell	0.15 "
Electromotive force of battery, per cell	1.95 volts.
Current required to explode fuses in series	0.675 webers.

In the above, the resistances of the wires and the battery and its electromotive force were revised by General Abbot with the elaborate electrical apparatus of the torpedo-school, who also furnished from his experiments the resistances of fuses at the moment of explosion and the amount of current required to explode fuses in series.

The batteries were manufactured by Charles T. Chester, the size of the plates being $4\frac{1}{2}'' \times 6''$, and the immersed portions $4\frac{1}{2}'' \times 4\frac{3}{4}''$.

The separate batteries were so arranged in two frames that all the cells could be immersed by the same operation.

The system, then, consisted of 3,680 mines and 23 batteries, each battery assigned to 160 mines, which were divided into 8 groups, of 20 each. The mines of each group were connected in continuous series, and a lead and return wire to the battery closed the circuit.

To insure the simultaneous discharge of the whole system "a circuit-closer" was introduced.

The method, which will be explained, for one division of 160 charges will suffice for the others.

One lead-wire from each group of the division, *i. e.*, eight in all, was connected with one pole of the battery. The other pole was then connected with a brass pin penetrating through a wooden horizontal disc, which, being let go by the run, would cause the brass pin to enter a cup filled with mercury, planted in a second wooden horizontal disc fixed in position. If the eight return wires of the same groups were then connected with the brass cup containing mercury, it is evident that when the brass pin entered the mercury-cup the circuit would be closed, and explosion would result. Obviously, if instead of one pin and one mercury-cup, 23 pins and 23 cups were attached respectively to the two discs, and the same connections as just described made for each and every division of 160 mines, a simultaneous explosion would result at the moment when the upper disc should fall upon the lower.

The upper disc was held over the lower one and apart from it by a cord passing upward and looped over the tin case of a torpedo, securely attached to a frame. This torpedo or cartridge of dynamite was provided with a detonator, from which two wires passed to a small battery situated 2,100 feet distant. The torpedo was fired by closing this circuit with a Morse's key—the cord being severed allowed the upper disc to descend upon the lower, and thus close the circuit of the great batteries.

Capt. James Mercur, Corps of Engineers, reported for duty August 5, 1876, and was assigned to the works at Hallet's Point as the critical period for the charging of the mines and laying down the electrical system approached, which operations he was to superintend. The arrangements for these had been nearly perfected, and there remained only the testing of the fuses, and to verify by the actual firing of an experimental grouping of fuses the reliability of the formula, in which his services were very valuable. From theoretic as well as from practical knowledge, this officer was proficient from the start in the work to which he was

assigned. Mr. Striedinger, under him, carried out the electrical system in its various details as already adopted.

This report should not close without honorable mention of Mr. Bernard Boyle, chief overseer, and of Mr. Andrew O. Dwyer, master-carpenter, whose faithful and efficient services during the long period in which they have been associated with the works cannot be too highly estimated; and also of Mr. Washington Isetts, in charge of steam-machinery, whose occasional services at Hallet's Point have been very valuable.

Mr. William Preuss had been the surveyor at the works almost since the commencement, and his duties have been performed with great accuracy and fidelity.

Messrs. A. Doerflinger and M. A. Lacy, besides having been associated at times with the surveys there, were, during the preparations for the explosion, engaged in calculating and tabulating the numerous charges, and in other duties which required accurate performance, much care and fidelity.

The siphon was started at 12.07 a. m. on the 23d September, and at 7.30 p. m. the excavations were filled to the level of the tide.

The mines were fired at 2 hours 50 minutes 3 seconds p. m. on September 24, 1876.

The explosion was distinguished by the absence of hurtful shocks in the atmosphere, in the water, or under ground.

The elevation of spray, vapor, and gases projected upward, reached to the height of 123 feet, measured at the center and highest point. The quantity of water actually raised was trifling, as evidenced by the almost total absence of a propagated wave. The explosive effort in the air was not perceptible, the glasses in buildings close to the dam, and of one in particular, *along the shore-line of the shaft itself*, not having in a single instance been broken.

The underground shock was trifling, but perceptibly felt in the cities of New York and Brooklyn. Along the line of the reef a little plastering was dislodged from a ceiling in a house 150 yards, and in two houses 600 yards, from the work.

The new facts obtained by this experience are:

1st. That an unlimited amount of explosives distributed in blast-holes in moderate charges, proportioned to the work to be done, thoroughly confined in the rock and tamped with water, may be fired without damage to surrounding objects.

2d. That an unlimited number of mines may be simultaneously fired by passing electric currents through the platinum-wire bridges of detonators.

A magneto-electric machine would have probably answered as effectually as the zinc-carbon-bichromate batteries, but its employment would not under the circumstances have been convenient.

Besides preliminary trials to test the passage of the current through the fuses, they were proved when put in the mines before and after the water was let in. At the last test two of the groups, of 20 charges each, failed to indicate a current through them. There were besides 782 charges which were never connected with the batteries, and were designed to be exploded by concussion. The number of those finally connected with the batteries was therefore 3,640, and of those not connected 822.

After the explosion, an early and thorough examination was made with divers, and up to this moment nothing has been discovered opposed to the confident belief felt in the complete demolition of the reef.

The contractor is at work removing the broken rock with a steam-grapple. The cost to the Government is $2.40 per ton of 2,240 pounds.

The total cubic contents demolished by the explosion were 63,135 cubic yards, solid. On the different suppositions for the broken débris, of once and a half and of twice the original volume, there would result respectively 94,702½ and 126,370 cubic yards. The amount of débris is, however, 86,992 cubic yards, leaving to be accounted for either 7,710½ or 39,378 cubic yards.

It is probable that some of the material broken fine by the explosion has been swept away by the currents, and also that a large amount has been sifted into the interstices of the broken mass.

The quantity of broken stone to be grappled in order to obtain a depth of 26 feet, at mean low-water, is 37,082 cubic yards; and to obtain a depth of 28 feet, 45,488 cubic yards measured in the pile. As, in order to obtain the first-named depth, the grapple must penetrate about 1½ feet lower, the total amount to be removed may be put at 60,000 tons, equivalent to 30,000 cubic yards, solid.

The amount expended for excavation and explosion at Hallet's Point has been	$952,105 77
Estimate for removing broken stone	160,000 00
Total cost after completion	1,112,105 77

Respectfully submitted.

JOHN NEWTON,
Lieut. Colonel Engineers, Bvt. Maj. Gen.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

SIMULTANEOUS IGNITION OF A NUMBER OF MINES.

The ignition of mines by electrical agency will depend upon the nature and arrangement of the batteries, the dispositions of the mines, and upon the kind of fuse or detonator.

For low-tension fuses the platinum-wire bridges are heated by the currents either from voltaic or magneto-electric batteries.

The general formula

$$C=\frac{E}{R+r_1},$$

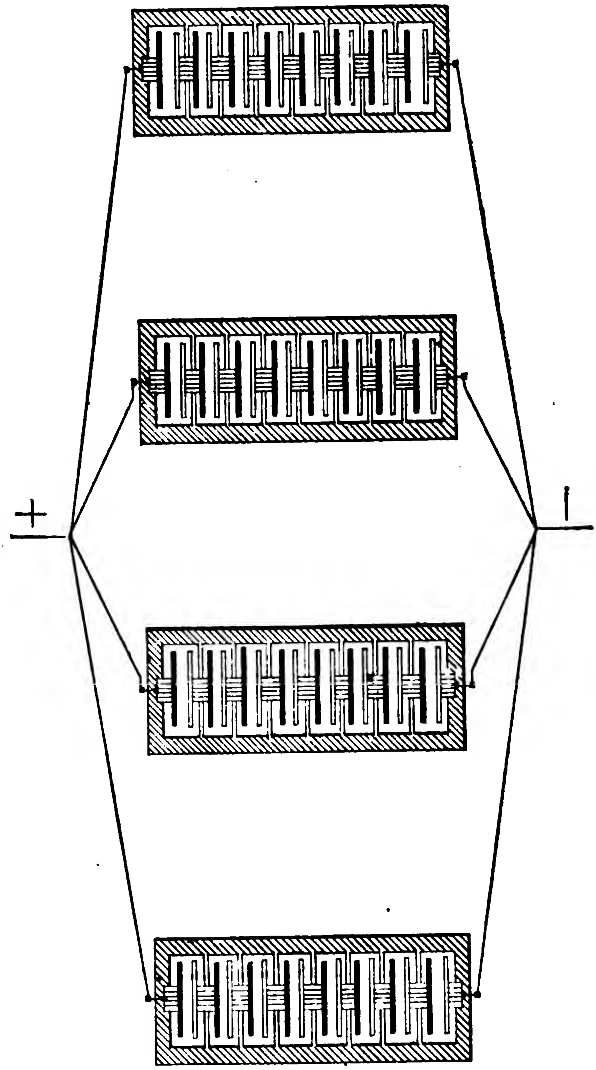
in which C is the current in webers, E the electro-motive force of the battery, R the internal and r_1 the external resistances, applies to voltaic, and, so far as tested, to magneto-electric batteries, in which the currents are continuously in the same direction.

This discussion will refer particularly to voltaic batteries, but by making proper substitutions will also apply to magneto-electric machines.

Any number of cells may be combined in series; that is, having the plates of opposite polarities in contiguous elements connected, and each element of the series may be composed of one or more single elements.

As with a given number of elements there may be many particular combinations, it is desirable to know which of these would prove to be most efficient, and would ignite the greatest number of mines.

But the combinations possible in grouping the mines are likewise many, and it is important to ascertain which grouping would lead to the best result.



This figure represents the system of combining the mines in series, by groups; that is, having the detonators of the mines of a group joined in regular sequence. A lead wire connects each end of a group with a pole of the battery.

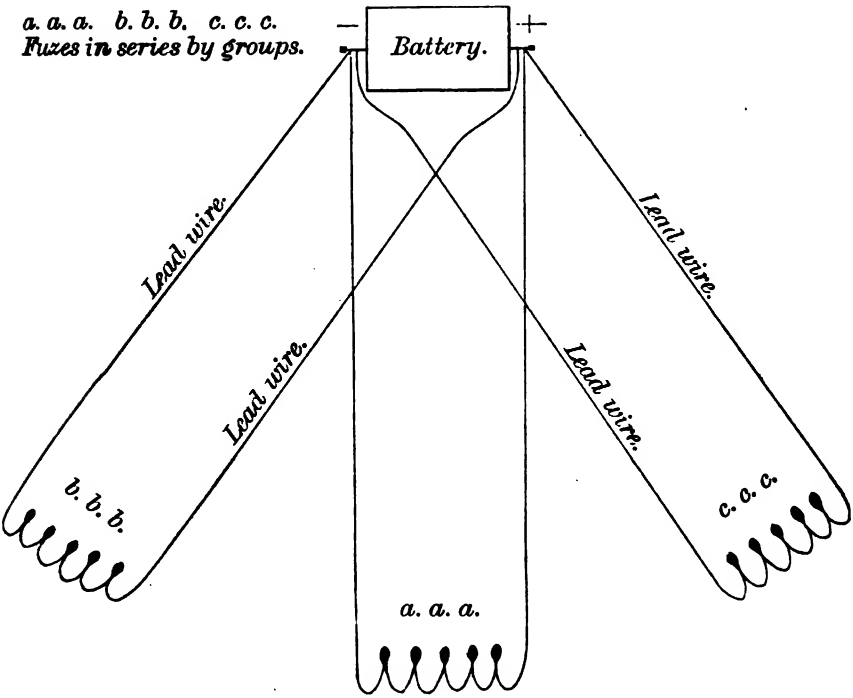
This arrangement is the most general, all other dispositions being but particular forms of it.

It is required to determine the number of groups, and the number of mines to a group.

The experiments at the torpedo school, Willets Point, showed great differences, (in resistances, and in webers of current necessary to ignite,) corresponding to different lengths and sizes of the platinum wire in the bridges; and the proper selection of a bridge for each case would amply compensate for the time bestowed upon this branch of the subject.

x = number of single elements to be combined = st;
t = number of elements in series, or number of batteries;
s = number of single elements in one battery or compound element;
f = resistance of one fuse at moment of ignition, plus that of its connecting wire;
e = electro-motive force of one element;
r = resistance of a single element;
N = number of fuses to be ignited;

n = number to each group;
c = number of webers of current required to ignite each group;
C = total number of webers;
l = resistance of lead wires to each group.
The resistances of all the groups in the system are supposed to be equal.



The variables are C, x, t, s, N, and n, and the quantities to be determined are x, t, $\frac{N}{n}$, and n.

In divided circuits, the principal current is equal to the sum of the partial currents, and hence:

$$C = \frac{N}{n} c = \frac{E}{R + r_1},$$

$$E = et,$$

$$R = \frac{rt}{s}$$

$$r_1 = \frac{nf + l}{\frac{N}{n}},$$

and by substitution in general equation:

$$C = \frac{N}{n} c = \frac{et}{\frac{rt}{s} + \frac{nf + l}{\frac{N}{n}}}, \text{(Eq. 1.)}$$

In a given combination of elements, the maximum effect is obtained when the total resistance in the elements is equal to the resistance of the external parts of the circuit.

That this law may not be misinterpreted, it must be noted that it supposes the ex-

ternal resistance cannot be arbitrarily varied, depending, as this does, upon the work to be done, which, again, must be in relation to the arrangement of the battery.

Differentiating C with respect to t, and placing the first differential co-efficient equal to zero:

$$\frac{r\,t}{s}=\frac{n\,f+l}{\frac{N}{n}},$$

or the internal equal to the external resistance.

From this relation combined with Eq. 1—

$$\frac{N}{n}=s\,\frac{e}{2\,c\,r}, \text{ (Eq. 2,)}$$

whence,

$$\frac{N\,t}{x\,n}=\frac{e}{2\,c\,r}$$

$$t=2\,c\,\frac{f\,n+l}{e}, \text{ (Eq. 3;)}$$

and

$$x=4\,\frac{N\,r\,c^2}{n\,e^2}\,(f\,n+l), \text{ (Eq. 4.)}$$

Before discussing these equations, it is well to remark that the same results would be obtained by differentiating $\frac{N}{x}$, x, or N with respect to t.

The values of $\frac{N}{n}$ and x obtained from the above simply correspond to particular values of t or n, which may be assumed, and are the best results for such particular cases; but it yet remains to find that combination which will make x a minimum, and furnish the corresponding values of n and $\frac{N}{n}$.

The relation—

$$\frac{N}{x}\times\frac{t}{n}=\frac{e}{2\,c\,r}, \text{ a constant,}$$

shows that as $\frac{t}{n}$ decreases, $\frac{N}{x}$ increases and x decreases; $\frac{t}{n}$, however, will decrease as n increases, and hence x is not only a decreasing function of n, but of t also. Since t and n are increasing functions of each other, x will therefore be a minimum when t is a maximum; that is, when $t=x$, or when the whole number of elements is combined in single series.

If l, the resistance of the lead wires to a group, be neglected, these would result:

$$t=\frac{2\,c\,f\,n}{e},\quad \frac{N}{n}=s\,\frac{e}{2\,c\,r},\text{ and } x=\frac{4\,N\,r\,c^2\,f}{e^2}.$$

As x here is independent of n or t, it follows that in whatever combination the elements, or the mines, may be arranged, (provided the equality of the external and internal resistances be preserved,) there will always result a constant value of x so long as N remains the same.

Reverting to Equations 2 and 4, when $x=t$,

$$s=1,\ \frac{N}{n}=\frac{e}{2\,c\,r}, \text{ a constant, (Eq. 5;)}$$

and

$$x=4\,\frac{N\,r\,c^2\,f}{e^2}+\frac{2\,c\,l}{e}, \text{ (Eq. 6.)}$$

When the problem of ignition is applied in practice, it must start with a given value of N or of x; assuming either, the values of x, N, n, and $\frac{N}{n}$ will be defined.

From Eq. 5 it appears that the number of groups will not vary from variation of the number of elements, as long as these are combined in single series.

By substituting value of t, Eq. 3, in Eq. 1,

$$C=\frac{N\,c}{n},$$

in which C and n are variables, and $C n = N c$; also, Eq. 4 gives,

$$x = 4 \frac{N r c^3 (f n + l)}{n e^2},$$

in which x and n are variables.

If n be laid off on axis of abcissas, and C and x upon axis of ordinates, there will be formed two curves, which it is proper here to discuss.

The second differential co-efficients of C with respect to n, and of n with respect to C, being of the same sign with the respective co-ordinates, the curve is convex toward both axes of co-ordinates;

$$n = 0; \frac{d c}{d n} = \infty;$$

that is, the axis of ordinates is one asymptote;

$$n = \infty; \frac{d c}{d n} = 0,$$

or the axis of abcissas is the other asymptote.

From Eq. 4,

$$\frac{d x}{d n} = - \frac{4 N c^2 r l}{n^2 e^2},$$

and a similar discussion holds true with respect to this curve.

$$C = \frac{N c}{n}$$

is the equation of a hyperbola referred to its center and asymptotes.

$$x = 4 \frac{N r c^3}{n e^2} (f n + l)$$

is the equation of a hyperbola referred to an asymptote as axis of ordinates, the axis of abcissas being parallel to the other asymptote, and at a distance from the center equal to

$$4 \frac{N r c^3 f}{e^2}$$

$a\ b$ is the curve of webers of current between the values of

$$n = 2 \text{ and } n = \frac{2 r c N}{e}.$$

The dotted portion results from assigning other positive values besides these to n in

$$\text{Eq. } C = \frac{N c}{n}.$$

In the same manner $c\ d$, is the curve of Eq. 4, giving number of elements required

$$\text{from } n = 2 \text{ to } n = \frac{2 r c N}{e};$$

and the dotted portion results by assigning other positive values besides those to n.

The line $e\ f$, parallel to axis of abcissas, corresponds to values of x from Eq. 4 when $l = 0$.

The value of c changes when n is made less than 2.

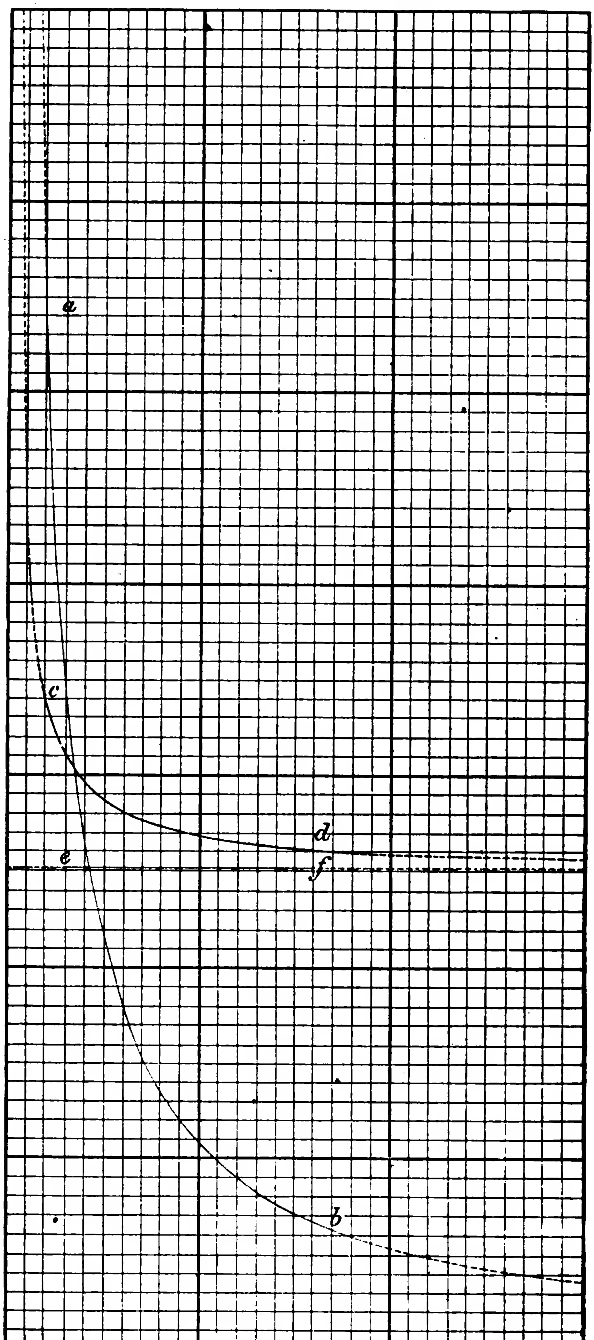
The results determined may be briefly summed up:

First. If the resistance of the lead wires be neglected the arrangement of the elements in the battery, or what is equivalent, the number of fuses in a group, may be assumed arbitrarily without changing the number of elements required to ignite a given number of fuses.

Second. When the resistance of the lead wires cannot be neglected, the best arrangement for the elements would be in a single series; such disposition requiring a minimum number of elements to a given number of fuses.

At Hallet's Point the resistance of the lead wires could not be neglected, and hence the second rule appeared to be applicable. By that rule, however, it would have become necessary to divide the number of mines, 3,680, into 9 groups of 409 mines each. There would have been great objections to stringing 409 fuses in continuous series, since a defect of connection in one would have prevented the ignition of the whole group.

SKETCH SHOWING THE CURVES.



Besides, the lengths of connecting and leading wires for mines situated in various parts of the galleries were quite different, and their electrical resistances correspondingly so. Hence it was found best to divide the whole number of mines into 23 divis-

ions of 160 each, subdividing each division into groups, and to appoint a separate battery to each division.

Notwithstanding this wide departure from the second rule, the excess in the number of elements required by it was only about 23.

Another point to be attended to is this: To give an excess of energy beyond that prescribed by the formulas to the battery, in order to compensate for deficiencies in insulation, imperfect connections, &c.

The amount of this excess will be determined in each instance by the above mentioned considerations and by preliminary trials in all important works.

General H. L. Abbot, Corps of Engineers, is the first electrician, it is believed, who has determined formulas which involve the number of fuses, the number in a group, the electromotive force of the battery, and the various resistances. The discussion above given aims at a complete solution of the explosion of mines by voltaic batteries.

D 3.

DREDGING MUD-BARS IN HUDSON RIVER, OPPOSITE JERSEY CITY.

An examination and survey of that portion of the river between the Jersey City Ferry and the Cunard docks, from which 163,639 cubic yards of material were removed during the fiscal year ending June 30, 1876, was made during the spring of 1877. This survey shows that the amount so excavated has been replaced by about 100,000 cubic yards of material, which has been washed in by the currents, leaving nearly the same depth of water as existed before the dredging was done.

No further dredging has been done during the year, and none is recommended until some plan of improvement which gives promise of being permanent is devised.

In this connection I would respectfully refer to letters upon this subject of Lieutenant-Colonel Newton of January 4 and April 5, 1877.

Collection-district, New York. Nearest port of entry, New York. Amount of revenue collected, $102,352,037.65. Amount of commerce to be benefited by completion of the work, ———.

ORIGINAL ESTIMATE.

Dredging 221,300 cubic yards, at 40 cents	$88,528 00
Contingencies and engineering	13,279 20
	101,807 20
Amount appropriated by act of Congress approved March 3, 1875	25,000 00
Amount expended	25,000 00

Money statement.

July 1, 1876, amount available	$101 05
July 1, 1877, amount expended during fiscal year	101 05
Amount (estimated) required for completion of existing project	76,807 20

LETTERS OF LIEUT. COL. JOHN NEWTON, CORPS OF ENGINEERS.

1.

UNITED STATES ENGINEER OFFICE,
New York, January 4, 1877.

GENERAL: Mr. Strickland Kneass, in his communication, reports that there is—

A shoal in the harbor of New York directly opposite the docks occupied by the Cunard line of European steamers at Jersey City, that seriously interferes with the movements of those vessels on their arrival and departure, &c.

I would respectfully recommend that an examination by accurate sur-

vey be made of this shoal as soon as the weather will permit, because if the statements of Mr. Kueass should be verified, it would prove to be the most conclusive argument against the application of further funds to dredge there, as the mud-shoal in front of the Cunard dock's was dredged for a length of 350 yards, and one year since to a depth of 28 feet at mean low-water.

I respectfully refer to the conclusions of my report upon the shoal off Jersey City, and published in the report of the Chief of Engineers for 1875, Part 2, and also to my letter of May 26, 1875, addressed to the Chief of Engineers.

Deferring to the experience to be furnished by an examination of the dredged portion of the shoal in front of Jersey City, and referring to the map sent with the report of February 1, 1875, by which it will be plainly perceived that the main ebb-current washes the New York shore, the present inference would be that, as long as the present state of things endures, deposits must take place on the New Jersey side faster or slower according to the scour in the channel, which again would depend upon the elongation of piers, diminishing the cross-section between New York and Jersey City.

No examination of currents above Castle Point has been made, but the soundings appear to indicate that the ebb-currents are thrown over to the New York side by deflecting from the New Jersey shore at or above Castle Point, and that the remedy appears to be to prevent this sharp deflection by a wall indicated upon the sketch or by cutting away Castle Point, the last being the heavier work.

It appears to be time to seek for the evil at its commencement, and to attempt a radical cure, and I recommend in case the examinations continue to prove unfavorable for the economical application of dredging, to make a thorough examination of the river at and above Castle Point in order to furnish therefrom a project for permanent improvement.

Very respectfully, general, your obedient servant,

JOHN NEWTON,
Lieut. Col. of Engineers, Bvt. Maj. Gen.

Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

2.

UNITED STATES ENGINEER OFFICE,
New York, April 5, 1877.

GENERAL: I have respectfully to transmit results of a survey made of the mud-shoal off Jersey City, in virtue of the authority contained in letter of January 30, last, from the office of the Chief of Engineers.

The amount of stuff removed by dredges during the interval of the two surveys recorded in the tracing was 163,639 cubic yards, measured in the scows, or, say, 112,000 cubic yards measured *in situ*. The actual difference, calculated from the chart, between the surfaces of the bed of the river, is only 14,777 cubic yards; leaving about 100,000 cubic yards to be accounted for by filling. This filling has undoubtedly been due to the flowing in of the mud from the sides of the excavation, as well as to the deposit of silt from eddies or slackened currents.

Under the revelations of this comparative chart, I cannot recommend the devotion of any more funds by the Government to dredging in front of the wharves of the Cunard line.

The remedy for the defect of filling in which takes place along the pier-line of Jersey City below Castle Point, and with more or less progress every year, does not lie in dredging.

Very respectfully, general, your obedient servant,

JOHN NEWTON,
Lieut. Col. of Engineers, Bvt. Maj. Gen.

Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., April 10, 1877.

SIR: Referring to the letter of Mr. Strickland Kneass, of the 10th November, 1876, calling attention to the shoal in the harbor of New York, directly opposite the docks of the Cunard line of steamers, and asking its removal by the United States, &c., I beg leave to say that by authority of the Secretary of War, dated January 13, 1877, a survey of the locality was made by Colonel Newton, Corps of Engineers, a copy of whose report thereon, with accompanying map, is herewith submitted.

About a year and a half since, the section near the docks of the Cunard line was dredged to a depth not less than 26 feet, and in many places a depth of 28 feet at mean low-water was reached, and the result of the survey just completed shows a large filling up since that period.

Colonel Newton says:

> Under the revelations of this comparative chart, I cannot recommend the devotion of any more funds by the Government to dredging in front of the wharves of the Cunard line.
>
> The remedy for the defect of filling in which takes place along the pier-line of Jersey City below Castle Point, and with more or less progress every year, does not lie in dredging.

I concur in his views.

The previous papers in the case are herewith returned.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brig. Gen. and Chief of Engineers.

Hon. GEO. W. MCCRARY,
Secretary of War.

[Indorsement.]

The Secretary of War approves the view of the Chief of Engineers.

By order of the Secretary of War.

H. T. CROSBY,
Chief Clerk.

APRIL 12, 1877.

D 4.

IMPROVING HARLEM RIVER, NEW YORK.

There being no appropriation for this work, no operations were conducted during the year.

This work is in the collection-district of New York. Nearest port of entry, New York. Amount of revenue collected for fiscal year ending June 30, 1876, $102,352,037.65. Amount of commerce to be benefited by completion of the work, ———.

ORIGINAL ESTIMATE.

I. Piers Nos. 1, 3, and 4, of old bridge off foot of East One hundred and fourteenth street, Harlem, 674.2 cubic yards, at $6 per cubic yard..	$4,045 20
II. Candle-Factory Reef, foot of East One hundred and twenty-second street, Harlem, 1,149.46 cubic yards, spread over an area of 2,529 square yards, at $72.81 per cubic yard	83,703 00
III. Flat rock off foot of East One hundred and twenty-fifth street, Harlem, 304 feet from Harlem shore, 333.6 cubic yards, spread over an area of 508 square yards, at $97.13 per cubic yard	32,404 00
IV. Small rock in midchannel off East One hundred and twenty-fifth street, Harlem, 470 feet from Harlem shore, 23.9 cubic yards, spread over an area of 122 square yards, at $194.56 per cubic yard	4,650 00
V. Small rock at mouth of Mott Haven Canal, 470.59 cubic yards, spread over an area of 261.2 square yards, at $45 per cubic yard	21,176 55
Contingencies, 15 per cent. of the above	21,896 82
Total	167,875 57
Amount appropriated:	
Allotment from appropriation "for continuing the improvements in East and Harlem Rivers," approved June 23, 1874	11,000 00
By act of Congress approved March 3, 1875	10,000 00
	21,000 00
Amount expended	21,000 00

Money statement.

Amount (estimated) required for completion of existing project	$146,875 56
Amount that can be profitably expended in fiscal year ending June 30, 1879.	50,000 00

D 5.

IMPROVING PASSAIC RIVER, NEW JERSEY.

The appropriation for this river not having become available until the 1st of April, 1877, but little work has been done, as the balance of former appropriations was nearly all expended during the last fiscal year.

Work was commenced in April upon the small drilling-scow to get it in order to commence operations, and on May 24 was towed to Belleville Bar, and the channel cleared of loose stones for a distance of about 75 feet. On the morning of the 3d of May, it was towed to Rutherford Park Bar, and work commenced for removing loose stones and bowlders from the sides of the cut made two seasons ago. From the time of commencing work to the end of the year, 395 cubic yards of stone had been removed, and 685 feet of channel cleared.

This work is in the collection-district of Newark, N. J. Nearest port of entry, Newark, N. J. Amount of revenue collected, $4,243.52. Amount of commerce to be benefited by the completion of this work, $1,000,000.

ORIGINAL ESTIMATE.

Middle Bar, dredging	$936 00
Middle Bar, diking	66,375 00
Belleville Bar, dredging	15,501 00
Rutherford Park Bar, dredging	14,112 00
Holoman's and small bars above, dredging	12,000 00
Contingencies	15,000 00
	123,924 00

Money statement.

July 1, 1876, amount available	$463 47
Amount appropriated by act approved August 14, 1876	10,000 00
	10,463 47
July 1, 1877, amount expended during fiscal year	1,898 01
July 1, 1877, amount available	8,565 46
Amount (estimated) required for completion of existing project	23,924 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	23,924 00

D 6.

IMPROVING EAST CHESTER CREEK, NEW YORK.

The State commissioners appointed to purchase and condemn the marsh land through which the proposed channel is to be cut, having completed their labor and secured to the United States the necessary ground and right of way, the work was advertised, and on March 31, 1877, contract was made with John Satterlee for dredging a cut 100 feet wide, at mean high-water mark, 9 feet in depth below mean high-water mark, and about 2,200 feet in length; in making this cut about 3,149 cubic yards of rock have to be excavated, and 1,210 feet of pile-dyke, and 140 feet of crib-dike, have to be built to revet a portion of the eastern bank of the cut.

Work was commenced about April 16, 1877, and at the close of the fiscal year the following work had been done:

906 cubic yards rock removed.
5,936 cubic yards mud dredged.

This work is in the collection-district of New York. Nearest port of entry, New York. Amount of revenue collected, $102,352,037.65. Amount of commerce and navigation benefited by completion of the work would be $2,238,203, annually.

ORIGINAL ESTIMATE.

Basin, purchase of site, 18 acres, at $150	$2,700 00
Excavation to level of mean low-water 200,000 cubic yards, at 40 cents.	80,000 00
Excavation of cut 60,000 cubic yards, at 40 cents	24,000 00
Diking and revetting banks of cut	12,000 00
Engineering and contingencies	17,800 00
	136,500 00
Amount appropriated:	
By act of Congress approved March 3, 1873	25,000 00
By act of Congress approved March 3, 1875	12,000 00
	37,000 00
Amount expended	7,281 13

Money statement.

July 1, 1876, amount available		$30,820 82
July 1, 1877, amount expended during fiscal year	$1,101 95	
July 1, 1877, outstanding liabilities	1,010 46	
		2,112 41
July 1, 1877, amount available		28,708 41
Amount (estimated) required for completion of existing project		99,500 00

Abstract of proposals for dredging, rock-cutting, and diking in East Chester Creek, New York, opened March 28, 1877.

Names.	Dredging 48,000 yards.	Rock-cutting 3,149 yards.	Diking. 1210 feet pile.	Diking. 140 feet crib.	Amount.
Thos. McCann	$0 22	$5 00	$5 20	$3 50	$33,087 00
John B. Healy	19	1 79	4 07	3 19	20,128 01
Peter W. Myers	22	2 48	4 10	4 10	23,904 52
James Dubois	26	3 00	5 00	3 00	28,397 00
Elisha G. Gay	20	2 75	3 86	2 38	23,963 55
John F. Ward	17	3 00	4 00	6 00	23,217 00
Edwin H. French	22½	2 50	4 00	6 00	24,352 50
John Beattie	25	6 50	5 00	4 95	39,211 50
Lafayette Lentz, John H. Byron, Dan'l C. Hickey	24	2 50	4 95	4 01	25,943 40
Cornelius Houlihan, John B. Doyle	11¼	2 59	3 87	3 87	19,080 41
John Satterlee	16	95	5 50	6 00	18,166 55
Caldwell B. Benson	28	3 25	3 00	3 00	27,724 25
James D. Leary	19½	2 83	3 48	3 48	22,969 67

Bids of Lentz, Byron, and Hickey not made in duplicate.

Abstract of contract for dredging, rock-cutting, and diking in East Chester Creek, New York.

Contractor's name and residence.	Date of contract.	Subject of contract.	Remarks.
John Satterlee, New York City.	Mar. 31, 1877	Removal of 48,000 cubic yards of alluvial earth, 3,149 cubic yards of rock, and constructing 1,210 feet of pile-dike, and 140 feet of crib-dike.	Commence work April 9, 1877, and complete the contract December 31, 1877.

D 7.

IMPROVING HARBOR AT PORT CHESTER, NEW YORK.

There being no appropriation for this work, no operations were conducted during the year.

Collection-district, New York. Nearest port of entry, New York. Amount of revenue collected, $102,352,037.65. Amount of commerce to be benefited by completion of this work, ——.

ORIGINAL ESTIMATE.

Removing rocks and building breakwater	$96,632 00
Amount appropriated by act of Congress approved June 10, 1872	12,000 00
Amount expended	9,800 00

Money statement.

July 1, 1876, amount available	$2,236 70
July 1, 1877, amount expended during fiscal year	36 70
July 1, 1877, amount available	2,200 00
Amount (estimated) required for completion of existing project	84,632 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	60,000 00

D 8.

IMPROVING HARBOR AT RONDOUT, NEW YORK.

During the winter of 1876 and 1877 the ice destroyed about 200 feet of the north dike, and caused considerable damage to other portions of the dike. This damage was repaired by rebuilding the destroyed portion, strengthening the pile-work, and refilling with stone the parts injured—3,149 cubic yards of stone being used.

Under appropriation of August 14, 1876, contract was made May 29, 1877, for the construction of the branch dike, 870 feet in length, and work was commenced about June 20, 1877. The channel south of the north dike is still much narrower than is desirable, and will require the completion of the original project before the improvement becomes permanent.

Rondout is in the collection-district of New York; nearest port of entry is New York; amount of revenue collected, $102,352,037.65; amount of commerce and navigation benefited by the completion of this work would be $80,000,000 annually.

ORIGINAL ESTIMATE.

North dike	$41,600 00
Branch dike	34,400 00
South dike	59,600 00
Dredging channel	14,400 00
Contingencies and engineering	22,500 00
Total	172,500 00
Amount appropriated:	
By act of Congress approved June 10, 1872	10,000 00
By act of Congress approved March 3, 1873	20,000 00
Amounts allotted June 8, 1875:	
From repairs of harbors on Atlantic coast	762 18
From contingencies of rivers and harbors, &c	237 82
By act of Congress approved August 14, 1876	30,000 00
	61,000 00
Amount expended	37,710 23

Money statement.

July 1, 1876, amount available	$9 31	
Amount appropriated by act approved August 14, 1876	30,000 00	
		$30,009 31
July 1, 1877, amount expended during fiscal year	6,719 54	
July 1, 1877, outstanding liabilities	5,193 90	
		11,913 44
July 1, 1877, amount available		18,095 87
Amount (estimated) required for completion of existing project		111,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		70,000 00

Abstract of bids for constructing pile-dike at Rondout Harbor, New York, opened May 24, 1877.

Bidders.	Price per linear foot.	Bidders.	Price per linear foot.
Fuller & Sons	$7 97	Francis Pidgeon	$9 25
John H. Marshall	8 81	Henry V. Sloat & Bro	5 97
Stephen Miles	12 67 for first 100 feet	Ross Sanford & Co	9 90
Do	6 05 for balance	Joseph L. Powley	7 95
Gilbert Earle	13 42	James D. Leary	10 49

Abstract of contract for constructing pile-dike at Rondout, New York.

Contractor's name and address.	Date of contract.	Subject of contract.	Remarks.
H. V. Sloat & Bro., Jersey City, N. J.	May 29, 1877	870 feet of pile-dike, more or less.	Commence work June 13, 1877, and complete same December 31, 1877.

D 9.

IMPROVING CHANNEL BETWEEN STATEN ISLAND AND NEW JERSEY.

No work has been done at this point during the year. The reasons which were assigned for not carrying out the original and extended project for improvement have gained additional weight by the establishment of a large coal-shipping port at Perth Amboy, thus removing almost entirely the coal-carrying trade from this channel.

Efforts are now being made to find out from those most largely interested in the improvement of this channel what, in their opinion, the needs of commerce require.

This work is in the collection-district of New York. Nearest port of entry, New York. Light-house, Bergen Point. Amount of revenue collected, ——. Amount of commerce to be benefited by the completion of this work, ——.

ESTIMATE OF BOARD OF ENGINEERS.

Dredging 230,000 cubic yards, at 16 cents	$36,800
Contingencies, 10 per cent	3,680

Money statement.

July 1, 1876, amount available	$229 74
Amount appropriated by act approved August 14, 1876	10,000 00
Total	10,229 74
Amount available	10,229 74
Amount (estimated) required for completion of existing project	30,480 00

D 10.

IMPROVING HARBOR OF PLATTSBURGH, NEW YORK.

During the year no operations have been conducted. Mr. D. White, assistant engineer, reports:

The navigation of North Plattsburgh Harbor, New York, has become much impaired by the formation of a bar or shoal extending eastwardly from the face of the "south dock" toward the breakwater, and thus contracting the channel to such an extent as

to render the ingress or egress of vessels, when the lake is at its normal stage, embarrassing. This shoal is principally the accumulation of silt from the wash and disintegration of the clay bluffs lying south of the harbor during the prevalence of southerly storms for the past nine years; a similar shoal, and in about the same locality, having been dredged in 1868.

The erection, within the past few months, of a wooden revetment extending several hundred feet along the base of the bluffs, by the New York and Canada Railroad Company, will in part, if not wholly, prevent in future the growth of such impediments. The removal of this shoal would greatly contribute to the well-being of general commerce.

Nearest port of entry, Plattsburgh, in the collection-district of Champlain. Amount of revenue collected last fiscal year, ———. Amount of commerce benefited by completion of this work, ———.

Money statement.

July 1, 1876, amount available	$4,941 52
July 1, 1877, amount available	4,941 52

D II.

IMPROVING HARBOR AT BURLINGTON, VERMONT.

Mr. D. White, assistant engineer, submits the following report:

The superstructure of an extension of 160 linear feet of breakwater, under contract with James D. Hancock, extending in a northerly direction, has been completed.

The repair of the 220 linear feet of the southern end of the breakwater, injured by ice-floes during the terrific storm in the month of February, 1876, has been commenced and is well advanced toward completion, the work having been carried up to within two courses of the necessary height, which latter, together with the 26 feet of crib for closing up the gap existing between the sundered section (of 220 feet) and the main body of the work, and other repairs near the northern end, will be completed between July 1 and October 3, 1877.

Burlington Harbor is a port of entry. Collection-district, Vermont. Nearest fort, Fort Montgomery, New York. Amount of revenue collected, $985,000.

Amount appropriated:

By act of Congress approved March 3, 1875	$25,000 00
By act of Congress approved August 14, 1876	20,000 00
	45,000 00
Amount expended	29,522 85

Money statement.

July 1, 1876, amount available	$7,590 71
Amount appropriated by act approved August 14, 1876	20,000 00
	27,590 71
July 1, 1877, amount expended during fiscal year	12,113 56
July 1, 1877, amount available	15,477 15
Amount (estimated) required for completion of existing project	295,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	50,000 00

D 12.

IMPROVING HARBOR AT SWANTON, VERMONT.

Mr. D. White, assistant engineer, submits the following report:

The superstructure of an extension of 69 linear feet of breakwater, under contract with James D. Hancock, has been completed.

Under the appropriation of August 14, 1876, of $2,000, no work has been done, as the amount is not sufficient to construct a crib large enough to withstand the pressure of ice brought against this work in the spring, and it is proposed to defer the construction of another crib until an additional appropriation is made.

Swanton Harbor is in the collection-district of Vermont. Nearest port of entry, Windmill Point. Nearest fort, Fort Montgomery, New York.

ORIGINAL ESTIMATE.

For 1,900 linear feet of breakwater	$272,160 00
Amount appropriated:	
By act of Congress approved March 3, 1873	15,000 00
By act of Congress approved June 23, 1874	8,000 00
By act of Congress approved March 3, 1875	10,000 00
By act of Congress approved August 14, 1876	2,000 00
	35,000 00
Amount expended	32,389 35

Money statement.

July 1, 1876, amount available	$3,411 85
Amount appropriated by act approved August 14, 1876	2,000 00
	5,411 85
July 1, 1877, amount expended during fiscal year	2,801 20
July 1, 1877, amount available	2,610 65
Amount (estimated) required for completion of existing project	237,160 00

D 13.

IMPROVING OTTER CREEK, VERMONT.

Mr. D. White, assistant engineer, submits the following report:

No appropriation was made for this work for the fiscal year ending June 30, 1877.

For completing the improvement of the channel and west side of the basin, the amount needed will be $43,146.

Vergennes is in the collection-district of Vermont. Nearest port of entry, Burlington, Vt. Nearest fort, Fort Montgomery, N. Y.

ORIGINAL ESTIMATE.

Dredging, dikes, and facine-work	$57,646 00
Removing trees	500 00
	58,146 00
Amounts appropriated:	
By act of Congress approved June 10, 1872	10,000 00
By act of Congress approved March 3, 1875	5,000 00
	15,000 00

Money statement.

July 1, 1876, amount available	$63 69
July 1, 1877, amount expended during fiscal year	7 85
July 1, 1877, amount available	55 84
Amount (estimated) required for completion of existing project	43,146 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	20,000 00

APPENDIX E.

ANNUAL REPORT OF LIEUTENANT-COLONEL J. D. KURTZ, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1877.

UNITED STATES ENGINEER OFFICE,
Philadelphia, Pa., July 13, 1877.

GENERAL: I have the honor to transmit herewith my annual reports for the river and harbor works in my charge for the fiscal year ending June 30, 1877.

Very respectfully, your obedient servant,

J. D. KURTZ,
Lieutenant-Colonel of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

E 1.

CONSTRUCTION OF PIER NEAR LEWES, DELAWARE.

The expenditure of the remainder ($28,500) of the appropriation of $30,000, made August 14, 1876, having been authorized, a contract was entered into with Messrs. Paulding, Kemble & Co., of the West Point Foundry, Cold Spring, N. Y., (the lowest bidders,) for the supply of 20 pile-shafts and all the parts belonging to them. One delivery of 10 shafts and corresponding parts has been made.

The substructure of the pier has been built out from 1,533 to 1,575 feet, or two rows of piles have been inserted in place. A steam-engine has been substituted for mules as the motive-power in lifting and placing the piles, with marked success.

Small appropriations, necessitating frequent suspensions and the stoppage of work from the fall of 1875 till the spring of 1877, have delayed the completion of this structure greatly. The machinery and appliances had deteriorated seriously, and it was necessary before commencing the season's work to rebuild and replace certain portions.

It is important that a sufficient amount to complete the work next season be appropriated, as it is scarcely probable that the expensive derrick and its platform will last longer.

The particulars of the operations to June 30, 1877, are given in the report of the officer, Capt. William Ludlow, Corps of Engineers, in immediate charge of the work, as follows:

During the latter part of April a partial beginning had been made by opening the buildings in which the material on hand was mainly stored, getting it out, and repairing and cleaning the buildings themselves.

During the long suspension of work, (since October, 1875,) a gradual but increasing

deterioration of all the property had taken place, and nearly the entire month of May was occupied in completing the preparations for a new season's operations.

The pier was completely constructed (with the exception of the fender system, which has not yet been commenced) to a distance of 1,386 feet from shore, the heavy timbering farther extending to 1,428 feet, and the iron-work, including the 73d bay, and attaining a distance of 1,533 feet from the zero of the abutment.

There were on hand 10 pile-shafts, with their complement of braces, &c., with which to begin work while awaiting the new deliveries of iron from the contractors.

As it had been determined to substitute steam for the mules previously used as the motive-power for the work, considerable modifications had to be made in the details of apparatus, the principal being in the main derrick, upon the platform of which the hoisting-engine was to be placed.

A considerable amount of new material, such as cordage, blocks, harness, iron, lumber, &c., was also required to replace what had become unserviceable and to render the apparatus thoroughly efficient.

During the last days of May the 74th row of piles (the first of the new work) was completed.

This row went down with unusual difficulty, as evidenced by the crushing of the cast-iron cams which in the screwing-down apparatus clamp the pile, and by the breaking of doubled chains of iron an inch in diameter which were put on to replace them.

A new cam was made of wrought iron with a steel face, which appeared able to withstand the pressure.

It was found that the cast-iron wheels and brackets used under the derrick to facilitate moving forward were soon crushed by the weight of the structure, and these, after once obtaining new ones, which were again broken, were replaced by sliding-shoes of yellow-pine timber bolted in pairs with a tongue between as a guide.

Early in June the 75th row of piles, 1,575 feet from shore, was set in place, exhausting the material on hand.

The resistance of these piles was much less than that of the preceding ones.

The contract called for the delivery of one complete bay on June 5, but as sending this down alone would have necessitated transportation by rail and left the iron at the railroad-pier at a considerable and inconvenient distance from the work, and as it was reported that a second bay would be ready by the 13th, it was decided to partially suspend operations from the 14th to such time as both bays could be delivered at once. The interval until the 23d, upon which day the schooner arrived from Cold Spring with the desired freight, (having been delayed by bad weather and head winds,) was improved by performing with a reduced force various necessary miscellaneous works, and by making such alterations and modifications of the apparatus as had shown themselves to be desirable.

A test was made of the strength of the 4-inch by 9-inch joists of the superstructure of the pier by constructing and loading with 8 piles, weighing about 81,000 pounds, an imitation bay of 6 inches greater span than in the pier.

The total average deflection under this superimposed weight was seven sixteenths of an inch.

Preparations were made for testing the weight-supporting capacity of the piles themselves, by loading one with 6 others on its cap, suitably supported, the pile to be tested being in the last row and unsupported except by its diagonal connection with the adjacent ones. This test was not completed before the end of the month, but was made on July 2, the center pile of the 75th row being loaded with 6 others, and exhibiting a result of no depression. The weight of 60,000 pounds thus thrown on one pile is much greater than in any probability it will ever have to bear, and is, in addition, largely within its capacity to withstand.

An additional delay was found to be occasioned by the absence of the outer longitudinal brace belonging to the outer row of piles. The lower collars to which these braces are attached are in 4 pieces, with 4 bolts and nuts, securing the lower ends of as many braces. As the diver could not, unaided, secure these at once, it becomes necessary to bolt them all together loosely and lower them over the head of the pile, after which the diver can set them up and the bracing can be completed. This difficulty was remedied by ordering an additional set of braces (longitudinal) from the contractors.

The bracing is the most tedious and uncertain part of the work, depending as it does upon the coincidence of favorable weather with low tides, the upper collars being at about the level of mean low-water.

The shafts, braces, and caps of eleven bays were painted with coal-tar, put on as hot as possible, the scale having been previously hammered off.

Some such expedient for protecting the pile-shafts from corrosion will probably be a yearly charge, as the prolonged grinding action of the ice will inevitably scour the iron and leave it again exposed.

A full and careful inventory of all materials on hand was completed in June.

It is to be regretted that the appropriation was insufficient to admit of furnishing

enough iron to complete the pier, of which two bays only will remain to be completed at the close of the season. The work could have been done for very little more than the cost of the iron, say $7,500.

During the present fiscal year work will be continued until the material for two more bays (now in process of manufacture by the contractors) is placed in the structure. This will about exhaust the present appropriation.

It is proposed next season to complete the pier proper; protect the pier-head by a suitable fender-system; lay out on each side, and off the end, a series of anchors, with buoys attached, for the convenience of vessels coming to and lying alongside the pier, and put down a railroad-track 2,700 feet in length, to connect the pier with the railroads of the locality.

The original estimated cost of the pier was	$387,419 67
Which was increased, on account of the advance in prices of iron and labor and the operations of the 8-hour law, by	24,000 00
	411,419 67
Total amount appropriated to June 30, 1877	$305,000 00
Total amount expended to June 30, 1877	284,253 80
Original estimated amount required to complete the work	106,419 67
Owing to the decreased price of iron and use of wood instead of iron in the fender-system, this sum may be decreased by	55,819 67
And the pier can now be completed for	50,600 00

Abstracts of proposals and contracts are herewith.

Money statement.

July 1, 1876, amount available	$75 43	
Amount appropriated by act approved August 14, 1876	30,000 00	
		$30,075 43
July 1, 1877, amount expended during fiscal year	9,253 80	
July 1, 1877, outstanding liabilities	9,500 00	
		18,753 80
July 1, 1877, amount available		11,321 63
Amount (estimated) required for completion of existing project		50,600 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		50,600 00

Abstract of proposals for iron for landing-pier, near Lewes, Delaware, received April 16, 1877.

No.	Name of bidder.	Total bid for material.	To commence	To complete	Remarks.
1	Paulding, Kemble & Co., Cold Spring, N. Y.	$10,433 83	Apr. 26, 1877	Aug. 15, 1877	
2	Patterson Iron Company, Patterson, N. J.	10,988 22	June 5, 1877	Aug. 5, 1877	
3	Macpherson, Willard & Co., Bordentown, N. J.	12,082 52	June 5, 1877	Aug. 5, 1877	
4	Seyfort, McManus & Co., Philadelphia, Pa.	14,981 82	June 5, 1877	Aug. 5, 1877	Guaranty blank.

Abstract of contract for constructing pier near Lewes, Delaware.

Date of contract.	Contractor.	Material.	Rates per pound, delivered.	To complete
Apr. 7, 1877	Paulding, Kemble & Co., Cold Spring, N. Y.	Rolled, hammered, and cast iron.	Braces, 4.9 cents; screw-bands, 8 cents; pile-shafts, 4 cents; screw-buckles, 15 cents; yokes, 15 cents; bolts and nuts, 9 cents; collars and clamps, 13 cents; screws and caps, 4.5 cents.	Aug. 15, 1877

E 2.

IMPROVING ICE-HARBOR AT NEW CASTLE, DELAWARE.

A contract for the removal of 110 feet in length of the coal-wharf below the piers, in addition to the 108 feet removed last year, has been executed, and the work has been commenced.

A contract has also been made for the construction of the crib foundation of a new ice-pier, under which work will be commenced early next month. This pier is the last contemplated by the present plan of improvement, and during the present fiscal year the foundation will be completed to the level of low-water, in readiness for the stone superstructure.

Next year it is proposed to complete this pier, and to dredge out the accumulated sediment, for which purposes an appropriation of $24,000 is asked.

New Castle is in the collection-district of Wilmington, Del., which is also the nearest port of entry. Fort Delaware is the nearest fort, and the Bulkhead Shoal range-light the nearest light-house.

Abstracts of proposals and contracts are herewith.

Total estimated cost of improvement	$120,000 00
Total amount appropriated	91,500 00
Total amount expended	77,081 73

Money statement.

July 1, 1876, amount available	$3,094 40
Amount appropriated by act approved August 14, 1876	12,000 00
	15,094 40
July 1, 1877, amount expended during fiscal year	676 13
July 1, 1877, amount available	14,418 27
Amount (estimated) required for completion of existing project	$28,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	24,000 00

Abstract of proposals for construction of an ice-pier, and for completion of the removal of the coal-wharf in the harbor at New Castle, Delaware, opened at 12 o'clock m., May 16, 1877.

No.	Name of bidder.	Construction of crib-work and platform complete.	For same, and *one* course of stone.	For same, and *two* courses of stone.	For same, and *three* courses of stone.	For same, and *four* courses of stone.	For same, and *five* courses of stone.	For pier complete.	Completion of removal of coal-wharf.	Remarks.
1	William H. Ward & Co., Worcester, Mass.	$12,200	$13,850 00	(*)	(*)	(*)	(*)	$22,000 00	....	
2	Ross & Sanford, Newark, N. J.	11,000	13,544 08	$16,070 52	$18,442 28	$20,884 23	$23,172 91	26,862 52	$6,500 or $43.33 per linear foot	
3	Peirce, Rowe & Co., Frankfort, Me., and Ira Lunt, New Castle, Del.	9,597	4,220 34	12,833 68	14,421 02	16,618 36	17,523 70	20,429 04	....	
4	Beattie & Dresser, New York City	....	....	....	....	....	....	....	....	Rates, per unit, given. Amounts not calculated.
5	Garrett Speer, Philadelphia	6,890	10,390 00	13,390 00	15,540 00	17,540 00	18,540 00	19,540 00	....	Guaranty blank.
6	J. Powell & Son, Philadelphia	10,643	12,273 00	13,978 00	....	....	....	21,243 00	....	
7	The American Dredging Company, Philadelphia.	10,285	11,807 90	13,330 80	14,853 70	16,376 60	17,899 50	21,018 50	4,000 00 4,870 00	For removal of outer crib. For removal complete.
8	Frederick Patterson, Constantia, N. Y.	....	....	....	....	....	....	....	9,000 00	For construction of pier, rates per unit given. Amounts not calculated.
9	Ira Lunt, New Castle, Del	....	....	....	....	....	....	....	5,343 00	

(*) $1,500 additional each course.

Abstract of contracts for improving ice-harbor at New Castle, Delaware.

Date of contract.	Contractors.	Nature of work.	Price.	To complete.
June 16, 1877.	American Dredging Company, Philadelphia, Pa.	Removing 110 feet coal-wharf.	$4,000	Dec. 31, 1877.
June 19, 1877.	Peirce, Rowe & Co., Frankfort, Me., and Ira Lunt, New Castle, Del.	Construction of wooden crib in place.	9,597	Nov. 10, 1877.

E 3.

IMPROVING HARBOR AT WILMINGTON, DELAWARE.

By the act of August 14, 1876, $16,000 were appropriated "for removing obstructions from, and the improvement of the harbor at Wilmington, Delaware."

The expenditure of the appropriation was not determined on until March 31, 1877. A project for its application was then submitted and approved, and advertisements issued under date of April 9, 1877, inviting proposals for dredging mud and removal of fast rock from the harbor. The proposals were opened on the 30th of April, 1877, and contracts awarded and executed, and operations for the removal of mud were commenced May 12, 1877, and for the removal of rock June 26, 1877.

The price bid for dredging was below the estimated price, which will admit of a larger amount of material being removed than was anticipated. The price for removal of fast rock is also below former rates.

During the interval between the suspension of operations for the improvement of this harbor, on March 31, 1876, and the resumption of work under the present appropriation, a gradual contraction of the channel has been going on, both in width and depth, at the several localities heretofore improved.

During the fiscal year ending June 30, 1877, 88,000 cubic yards of soft mud have been removed from this harbor from the following localities, namely: From the channel-way, just above the Christiana light-house, and advancing up stream for 1,250 feet, 33,000 cubic yards; from a point in the channel about 2,500 feet below the mouth of Brandywine Creek, advancing up stream for 1,500 feet, 22,000 cubic yards; along the north side of the channel, above the mouth of Brandywine Creek, extending up stream above Third street to a point on the prolongation of Front street, 26,000 cubic yards; and from the south side of the channel-way, above Market street, 7,000 cubic yards.

The result of these improvements has been to re-open the channel just above the light-house, and above Third street to Front, and just above Market street, to the width of 150 feet and depth of 12 feet, at mean low-water. The channel, commencing at a point 2,500 feet below the mouth of Brandywine Creek, and advancing up stream, has been increased in depth so as to afford fully 12 feet at mean low-tide, and a width of 150 feet.

The contractor for the removal of fast rock from the south side of channel below Third street has machinery adapted for the work in position, and is operating successfully.

During the present season it is proposed to complete the work under existing contracts by the removal of about 5,000 cubic yards of mud deposit from the channel, near the mouth of Brandywine Creek, and the removal of about 210 cubic yards of fast rock.

Next season it is proposed to continue the improvement of the harbor, on the north side of the channel, just above the buoy depot, for 1,200 feet up stream; along the south side of the channel from the Christiana Iron Company's wharf, up stream to the mouth of Brandywine Creek; the removal of a point that protrudes into the channel on the south, just above the mouth of Brandywine Creek, and along the north side of the channel from opposite the Lobdell Works, up stream to near Market street. This will require the removal of about 80,000 cubic yards of material, and will require an appropriation of $17,000.

Wilmington is in the collection-district of Delaware, and is a port of entry. The nearest light-house and fort are, respectively, Christiana light and Fort Delaware.

The amount of revenue collected at Wilmington during the fiscal year ending June 30, 1877, is $6,814.65, and at Philadelphia $6,410,594.

Abstracts of proposals and contracts are herewith.

The original estimate for improving Wilmington Harbor, Delaware	$83,000 00
Total amount appropriated to June 30, 1877	63,000 00
Total amount expended to June 30, 1877	56,419 00

Money statement.

July 1, 1876, amount available	$120 29	
Amount appropriated by act approved August 14, 1876	16,000 00	
		$16,120 29
July 1, 1877, amount expended during fiscal year	3,606 48	
July 1, 1877, outstanding liabilities	5,932 80	
		9,539 28
July 1, 1877, amount available		6,581 01
Amount (estimated) required for completion of existing project		20,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		17,000 00

Abstract of proposals for improvement, by removal of fast rock, of Wilmington Harbor, Delaware, received April 30, 1877.

Number.	Name of bidder.	Rate per cubic yard.	To begin—	To complete—	Remarks.
1	Frederick Patterson	$7 40	June 1, 1877	Aug. 1, 1877	Rate in this proposal was changed, by letter received before bids were opened, to $27.47.
2	Thomas Cummings	24 50	May 15, 1877	Aug. 1, 1877	
3	O. J. Jennings	28 00	May 30, 1877	Oct. 30, 1877	
4	George W. Townsend	37 00	Oct. 1, 1877	June 30, 1878	
5	American Dredging Company	30 00	May 7, 1877	June 30, 1877	

Abstract of proposals for improvement, by dredging, of Wilmington Harbor, Delaware, received April 30, 1877.

No.	Name of bidder.	Rate per cubic yard.	To begin—	To complete—	Remarks.
1	S. F. Shelbourne	14¼ c	July 1, 1877	Dec. 15, 1877	
2	Morris & Cumings Dredging Company.	17 c	30 days after signing papers.		Guarantors not certified.
3	American Dredging Company	10 c	May 7, 1877	June 30, 1877	
4	J. H. Fenner	*a*10 c., *b*11 c., *c*12½ c., *d*14 c.	May 10, 1877	Aug. 20, 1877	
5	Frederick Patterson	17 c	June 10, 1877	Nov. 1, 1877	

a 10 c. above Christiana light-house. *b* 11 c. below mouth of Brandywine Creek. *c* 12½ c. above mouth of Brandywine Creek. *d* 14 c. above Market street.

Abstract of contracts for improving harbor at Wilmington, Delaware.

Date of contracts.	Contractor.	Nature of work.	Rate per cubic yard.	To complete—
May 12, 1877	American Dredging Company, Philadelphia, Pa.	Dredging mud	$0 10	June 30, 1877
May 16, 1877	Thomas Cummings, New York City ..	Removing fast rock.....	24 50	Aug. 1, 1877

E 4.

IMPROVING HARBOR AT MARCUS HOOK, PENNSYLVANIA.

During the fiscal year ending June 30, 1877, no expenditure of funds has been made at this harbor, its condition being substantially the same as mentioned in the last annual report. The harbor, though small, proved of much value to commerce during the past winter, the record kept showing that 208 vessels, mostly large ones, sought this harbor for protection from the heavy moving ice in the Delaware from December, 1876, to about the middle of February, 1877.

The only repairs required to the ice-piers are at the upper outer one, a portion of the top course of which has been moved slightly on its bed, and the down-stream stone mooring-post of which has in consequence been moved very triflingly from its original position. The two wooden landing-piers, which are used during severe winters in connection with the detached piers, show the effect of the severe storm and high tide of last September. No timber was displaced, but the earth-filling was badly washed away. The upper timbers to these shore-piers have deteriorated rapidly the past year, and require prompt repairs, which, with those required by the upper outer stone pier, will cost about $2,200.

It is proposed to examine these piers with a view of placing an enrockment around their bases, if found necessary.

Money statement.

July 1, 1876, amount available	$6,701 91
July 1, 1877, amount expended during fiscal year	359 00
July 1, 1877, amount available	6,342 91

E 5.

IMPROVING ICE-HARBOR AT CHESTER, PENNSYLVANIA.

By the act of August 14, 1876, $2,600 were appropriated "for the construction of ice-harbor at Chester, Pennsylvania."

The expenditure of the appropriation was authorized December 2, 1876. A project was submitted January 6, 1877, and subsequently approved, for repairing the ice-piers and bulkhead of the upper line, and the reconstruction of the two connecting bridges. The limited amount of the appropriation made it advisable to do the work by hired labor and

purchase of materials in open market, for which authority was received from the Chief of Engineers.

Owing to the continuation of cold weather, with considerable frost in the ground, and to the harbor continuing filled with vessels moored to the piers, operations on the repairs did not commence until the latter part of February, 1877, after which they were continued without serious delay till about May 1, completing the repairs to piers and bulkhead, and the reconstruction of the two connecting bridges.

The materials purchased and used, superintendence, labor, and office expenses in doing this work, with the cost of same, were as follows:

For white pine timber	$535 21
For yellow pine timber	280 00
For oak timber	59 34
For iron	245 19
For earth filling	96 00
For painting	30 00
For superintendence, $410; workmanship, $844.26	1,254 00
For office expenses	100 00
	2,600 00

The condition of the ice-pier, bridge, and causeway on the lower line is substantially the same as reported last year.

This harbor, though not generally resorted to as a harbor of refuge, was quite valuable the past winter. It afforded shelter for about 25 large-class schooners, several tug-boats and barges, and 1 dredging-machine.

Chester is steadily increasing both in population and manufactures. One of the largest iron-ship-building establishments in the United States is located here.

Chester is in the collection-district of Philadelphia. The nearest port of entry, light-house, and fort are respectively Philadelphia, Fort Mifflin light, and Fort Mifflin.

The amount of revenue collected at Philadelphia during the fiscal year ending June 30, 1877, was $6,410,594.

Money statement.

Amount appropriated by act approved August 14, 1876	$2,600 00
July 1, 1877, amount expended during fiscal year	2,600 00

E 6.

IMPROVING SCHUYLKILL RIVER, PENNSYLVANIA.

By the act of August 14, 1876, $20,000 were appropriated "for the improvement of the Schuylkill River, Pennsylvania." Subsequently $15,000 of this sum were allotted for expenditure by letter from the office of the Chief of Engineers of September 15, 1876, and the balance of $5,000 by letter of April 30, 1877.

Projects for the expenditure of each of these amounts were submitted and approved.

During the fiscal year ending June 30, 1877, the improvement of this river has been directed to deepening of the channel, from its mouth up stream to opposite the outlet of the back channel north of League Island, so as to afford 24 feet depth of water at ordinary low tide, with a width of 150 feet.

This work is being executed under contract with Morris F. Brainard, of Albany, N. Y., dated November 16, 1876. Operations in dredging

commenced the latter part of November, 1876, and continued until cold weather, when the machinery was withdrawn for the winter. Work was resumed early in March, 1877, and is now in progress.

The result of these operations to July 1, 1877, has been the excavation of a channel from the 24-foot curve in the Delaware, up stream for about 3,500 feet, with a width of 80 feet for a distance of 2,600 feet, and 50 feet in width for the remaining distance, affording 24 feet depth of water at ordinary low tide. About 50,000 cubic yards of material have been removed.

The improvement in progress at this point is a modification of the original project for the improvement of this river, as recommended in my report for 1875. It is to enlarge the cut from the Delaware into the Schuylkill until it shall have a width of 300 feet, and a depth of 24 feet at low-water.

During the present season it is proposed to continue the dredging at the mouth, increasing the width of the channel with each cut, and effecting a depth in accordance with the project.

Under the allotment of $5,000, advertisements were issued inviting proposals, which were opened June 4, 1877, and a contract awarded and executed.

It is proposed to expend this amount by continuing the improvement of the river near Gibson's Point, which will admit of the removal of about 18,000 cubic yards of sand, gravel, and stones. This work is expected to be executed during the present season.

During the next fiscal year it is proposed to continue the improvement of the river by completing the deep channel at the mouth; by removing about 3,000 cubic yards of gravel from the east side of the cut just above Penrose Ferry bridge, so as to make a uniform width to the channel at that locality; by removing 400 cubic yards of fast rock from the channel off "Gibson's," and about 50,000 cubic yards of sand and gravel from the channel-way between "Gibson's" and Gray's Ferry bridge. The last-mentioned work to be with a view of affording 18 feet depth of water at ordinary low-tide. This will require an appropriation of $65,000.

The trade and commerce benefited by this improvement embrace foreign trade in grain and petroleum, (which is very large, as the following statement will show,) lumber and marble, and domestic trade in lumber, granite, &c.

OFFICE OF PETER WRIGHT & SONS,
Philadelphia, July 6, 1877.

Number of vessels at Point Breeze from June 30, 1876, to June 22, 1877, inclusive: Steamers, 2; ships, 32; barks, 199; barkentines, 3; brigs, 40; schooners, 45; sloops, 2; barges, 52; total, 375.

Amount of petroleum and its products shipped from Point Breeze from July, 1876, to June, 1877, inclusive: Refined, 363,859; crude, 338,278; benzine, 38,821; total, 740,959 barrels.

Number of vessels at and shipment of grain from Girard Point elevator from July, 1876, to June, 1877, inclusive: Steamers, 26; ships, 15; barks, 282; brigs, 6. Total vessels, 329; total bushels, 12,500,000.

Number of vessels at and estimated shipments of petroleum from Gibson's Point from July, 1876, to June, 1877, inclusive: Ships, 13; barks, 109; brigs, 11; schooners, 2; barges, 98. Total vessels, 233; total barrels, 223,000.

PETER WRIGHT & SONS.

Original estimated cost of improvement	$257,700 00
Increased estimate of 1874, ($40 per cubic yard for rock instead of $25)	42,000 00
Increase as recommended in last year's report for additional depth and width at the mouth of the river	75,000 00
	374,700 00
Total amount appropriated	165,000 00
Total amount expended	156,469 00

This work is in the collection-district and port of Philadelphia. The nearest light-house is Fort Mifflin light. The nearest fort is Fort Mifflin.

The amount of revenue collected at Philadelphia during the fiscal year ending June 30, 1877, was $6,410,594.

Abstracts of proposals and contracts are herewith.

Money statement.

July 1, 1876, amount available	$99 85	
Amount appropriated by act approved August 14, 1876	20,000 00	
		$20,099 85
July 1, 1877, amount expended during fiscal year	6,096 06	
July 1, 1877, outstanding liabilities	2,534 71	
		8,630 77
July 1, 1877, amount available		11,469 08
Amount (estimated) required for completion of existing project		209,700 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		65,000 00

Abstract of proposals for improving Schuylkill River, Pennsylvania, received November 2, 1876.

Number.	Name of bidder.	Rate, cubic yard.	To commence—	To complete—
		Cents.		
1	E. H. French, Volney, Oswego Co., N. Y	30	When required	When required.
2	Charles J. De Graw, Volney, Oswego Co., N. Y	14	Nov. 20, 1876	Nov. 20, 1877.
3	Edgar M. Payn, Albany, N. Y	26	Apr. 10, 1877	June 30, 1877.
4	Morris & Cumings Dredging Company, New York City	20½	Apr. 1, 1877	May 21, 1877.
5	Morris F. Brainard, Albany, N. Y	11½	Nov. 8, 1876	June 30, 1877.
6	American Dredging Company, Philadelphia	12½	Nov. 6, 1876	June 30, 1877.

Abstract of proposals for improving Schuylkill River, Pennsylvania, received June 4, 1877.

Number.	Name of bidder.	Dredging, rate per cubic yard.	To commence	To complete
		Cents.		
1	S. F. Shelbourne	19	July 1, 1877	Oct. 1, 1877.
2	The American Dredging Company	21	July 2, 1877	Nov. 1, 1877.
3	M. F. Brainard	18	Sept. 15, 1877	Nov. 30, 1877.

Abstract of contracts for improving Schuylkill River, Pennsylvania.

Date of contract.	Contractor.	Locality.	Character of dredging.	Rate, cubic yard.	To complete.
				Cents.	
Nov. 16, 1876	M. F. Brainard, Albany, N. Y.	From mouth up stream	Mud and sand	11½	June 30, 1877.
July 11, 1877	M. F. Brainard, Albany, N. Y.	Gibson's Points	Sand, coarse gravel, and stone.	18	Nov. 30, 1878.

E 7.

IMPROVING DELAWARE RIVER, BELOW PETTY'S ISLAND.

By act approved August 14, 1876, $40,000 were appropriated for this improvement, and under an allotment from this amount of $35,000 by

letter from the Chief of Engineers of September 15, 1876, a project for the expenditure of this sum was submitted and approved, and advertisements issued inviting proposals for the improvement of the river at Fort Mifflin Bar. A contract for the work was awarded to and executed with the American Dredging Company of this city. The contractors commenced operations in dredging about the middle of November, 1876, and, excepting the winter months, the improvement has been in progress since that time without cessation.

Under this contract the work has been applied to the removal of additional material from Fort Mifflin Bar, along the westerly side of the improved channel near its entrance into the New Jersey Channel on the south, so as to give increased width to the channel through the bar at that point, and to remedy the tendency of the southerly edge of the bar from extending into the New Jersey channel.

The cut of 22 feet depth of water at low-tide continues here, excepting a small area at its northerly end, near the entrance to the Pennsylvania Channel. This will be remedied by the removal from the bar at this end of a triangular piece similar to that now being removed at the southwesterly end of the channel.

The work of the past year for the improvement of this river has been the removal of about 100,000 cubic yards of sand at Fort Mifflin Bar, and the removal of a wreck from the north side of the channel about a half-mile below the Horseshoe Buoy.

During the present season it is proposed to complete the widening of the cut at the south end of the improved channel at Fort Mifflin Bar, and commence and complete the removal of the triangular portion of the bar adjoining the improved channel at its entrance to the Pennsylvania Channel north. This will require the removal of about 50,000 cubic yards of material. The unallotted balance of $5,000 for the improvement of the Delaware River below Petty's Island having been made available April 30, 1877, a project for its expenditure will be submitted as soon as the work now in progress at Fort Mifflin Bar approaches completion. With the balance of the appropriation it is proposed, after completing the work now in progress, to remove a wreck from the channel a short distance above Pea-Patch Island, (Fort Delaware,) and one from the channel north of the buoy of the "Middle" Delaware Bay, and to resume the improvement of the channel at Bulkhead Shoals by dredging away a projecting point on the northern and western side of the channel.

A careful survey should be made of the improvement at Fort Mifflin Bar, (to embrace an area of a half-mile each side of the channel,) to determine what additional work, if any, is required there.

During next season it is proposed to continue the improvement of the channel of the river at Bulkhead Shoals by dredging at the locality where work was suspended in the fall season of 1875, so as to deepen and straighten the channel, and afford 21 feet depth of water at ordinary low-tide.

Vessels with a draught of 22 feet now pass through the cut at Fort Mifflin Bar at any stage of the tide. The benefit to commerce derived from this improvement is of great value to Philadelphia. The foreign trade of Philadelphia for 1876 aggregated nearly $71,000,000; a much larger sum than was reached by the trade of any previous year.

Original estimated cost of improvement	$275,000 00
Total amount appropriated	40,000 00
Total amount expended	19,326 03

Abstracts of proposals and contracts are herewith.

Money statement.

Amount appropriated by act approved August 14, 1876		$40,000 00
July 1, 1877, amount expended during fiscal year	$14,163 95	
July 1, 1877, outstanding liabilities	5,162 08	
		19,326 03
July 1, 1877, amount available		20,673 97
Amount (estimated) required for completion of existing project		235,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		100,000 00

Abstract of proposals for improving Delaware River, at Fort Mifflin Bar, received November 2, 1876.

Number.	Name of bidder.	Rate, cubic yard.	To commence—	To complete—
1	E. H. French, Volney, Oswego County, New York	$0 35	When required	When required.
2	Charles J. De Graw, Volney, Oswego County, New York.	12	Nov. 20, 1876	Nov. 20, 1877.
3	Morris & Cumings Dredging Company, New York City.	23	May 1, 1877	Oct. 30, 1877.
4	American Dredging Company, Philadelphia, Pa.	16	Nov. 6, 1876	June 30, 1877.
5	Morris F. Brainard, Albany, N. Y	17½	Nov. 8, 1876	June 30, 1877.

Abstract of contract for improving Delaware River, below Petty's Island.

Date of contract.	Contractor.	Locality.	Character of dredging.	Rate, cubic yard.	To complete—
Nov. 17, 1876	American Dredging Company, Philadelphia, Pa.	Fort Mifflin Bar.	Sand, mud, and gravel.	$0 16	June 30, 1877.

E 8.

IMPROVING DELAWARE RIVER, BETWEEN TRENTON AND WHITE HILL, NEW JERSEY.

There was no appropriation made for this work by the last session of Congress, and nothing has been done since operations were suspended in the fall season of 1875. At that time a channel had been excavated around Periwig Island, with a width of not less than 125 feet, affording 6 feet depth of water at low tide.

Should an appropriation be made for this work for the next year, it is proposed to continue the improvement of the channel at this locality in maintaining its depth and increasing its width.

An appropriation of $10,000 for the next fiscal year is asked for continuing the improvement of the river between Trenton and White Hill.

Trenton is in the collection-district of Burlington, Philadelphia being the nearest port of entry. The nearest light-house and fort are, respectively, Fort Mifflin light

and Fort Mifflin. The revenue collected at Philadelphia during the year ending June 30, 1877, amounted to $6,410,594.

Original estimated cost of the work	$75,000 00
Total amount appropriated to June 30, 1877	45,000 00
Total amount expended to June 30, 1877	45,000 00

Money statement.

Amount required for completion of work	$30,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	10,000 00

E 9.

IMPROVING BROADKILN RIVER, DELAWARE.

No work has been done at the improvement of this river since the spring of 1874, when the appropriation of $10,000 was exhausted.

Should an appropriation be made by Congress, it is proposed next season to continue the original project for the improvement by dredging the river at the shoal places, and by opening an inlet into the bay at the junction of the Broadkiln and Lewes Creeks.

This work is in the collection-district of Wilmington, Del., which city is the nearest port of entry. Fort Delaware is the nearest fort, and Delaware Breakwater light is the nearest light-house.

Original estimated cost of the work	$80,447 00
Total amount appropriated to June 30, 1877	10,000 00
Total amount expended to June 30, 1877	10,000 00

Money statement.

Amount required for completion of the improvement	$70,447 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	10,000 00

E 10.

IMPROVING THE NORTH AND SOUTH BRANCHES OF THE SHREWSBURY RIVER, NEW JERSEY.

No work has been executed for the improvement of this river since 1873, when operations ceased for want of funds.

During the years 1871, 1872, and 1873, $19,000 were expended in dredging at various points on this river. Since then several changes in the channel have occurred.

During the season of 1875 a partial survey of the north branch and main river was executed, a report of which was submitted in my annual report for 1876.

It is proposed next season to continue the improvement by dredging the channel at Upper and Lower Rocky Points, and constructing a deflecting-dike at the latter. An appropriation of $18,000 is asked for these purposes.

Shrewsbury River is in the collection-district of Amboy; fort at Sandy Hook is the nearest fort; and Navesink lights are the nearest light-houses.

Total amount appropriated to June 30, 1877	$19,000 00
Total amount expended to June 30, 1877	19,000 00

Money statement.

Amount (estimated) required for completion of existing project	$18,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	18,000 00

E 11.

IMPROVING COHANSEY CREEK, NEW JERSEY.

This improvement remains in an incomplete condition, no appropriation having been made for this work for the last three fiscal years.

An appropriation of $10,000 is asked for continuing the improvement in accordance with the project submitted December 9, 1872.

Original estimate of cost	$30,000 00
Total amount appropriated to June 30, 1877	10,000 00
Total amount expended to June 30, 1877	10,000 00

Cohansey Creek is in the collection-district of Bridgeton, N. J., which is the nearest port of entry. Fort Delaware is the nearest fort, and Cohansey light is the nearest light-house.

Money statement.

Amount (estimated) required for completion of existing project	$20,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	10,000 00

E 12.

DELAWARE BREAKWATER.

This work remains substantially in the same condition that it did at the date of the last annual report.

The Western Union Telegraph Company have a station on the breakwater with shore connection, as reported last year.

Appended hereto is a table showing the number of vessels seeking refuge in the breakwater harbor annually for 13 years, and their total for 37½ years between 1833 and 1877.

Statement of vessels taking refuge in Delaware Breakwater Harbor during the years stated below.

Year.	Ships.	Barks.	Brigs.	Schooners.	Sloops.	Pilot boats.	Steamers.	Total.	Remarks.
1833	22	....	178	372	167	127	......	866	
1838	165	....	732	3,191	765	685	......	5,538	
1842	107	....	1,060	5,335	802	794	......	8,098	
1847	342	....	1,937	7,742	358	874	......	11,253	
1854	35	247	1,085	5,098	90	....	114	6,669	
1862	55	239	879	8,087	253	....	246	9,759	
1867	113	290	825	8,000	307	....	279	9,814	
1872	119	639	1,008	8,588	522	923	629	12,428	
1873	192	877	867	13,976	734	....	844	17,490	Pilot-boats classed with schooners.
1874	166	605	623	9,797	477	....	781	12,449	
1875	222	804	581	9,527	420	....	843	12,397	
1876	370	2,762	587	10,382	447	....	945	15,493	
From Jan. 1, 1877, to July 1, 1877.	377	2,784	417	4,684	206	....	514	8,982	Six months' return.
Total for 37½ years	6,435	13,778	32,653	232,781	17,035	13,685	9,600	325,970	

E 13.

PORT WARDEN'S LINE, PHILADELPHIA, PENNSYLVANIA.

This question remains as last reported, nothing on the subject having been heard from the municipal authorities of Philadelphia.

A bill has passed both branches of the city councils providing for the widening of Delaware avenue by about 30 feet, for the purpose of allowing a railroad-track to be laid down on that avenue. This will require some steps to be taken to recover the warehouse space, which will be encroached upon by the street when it is widened.

APPENDIX F.

ANNUAL REPORT OF MAJOR WM. P. CRAIGHILL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1877.

UNITED STATES ENGINEER OFFICE,
Baltimore, Md., July 12, 1877.

GENERAL: I have the honor to forward herewith the annual report for the year ending June 30, 1877, for works of improvement of rivers and harbors, and of surveys, which have been in my charge.

Efforts have been made to procure full statistics as to the commercial importance of each improvement, as required by instructions from the Chief of Engineers and in compliance with law. These efforts have not been entirely successful.

Very respectfully, your obedient servant,

WM. P. CRAIGHILL,
Major of Engineers, Brevet Lieut. Col., U. S. A.

Brig. Gen. A. A. AUMPHREYS,
Chief of Engineers U. S. A.

F 1.

IMPROVEMENT OF CHESTER RIVER AT KENT ISLAND NARROWS, MARYLAND.

The object of this improvement consists in dredging a channel 100 feet in width and 7 feet in depth, at ordinary low-water, from Chester River to Easton Bay, including the cutting of a passage through the causeway across the narrows.

As stated in previous annual reports, the work was delayed until the spring of 1875, while waiting for certain State legislation, without which it was not deemed expedient for the General Government to proceed.

The first appropriation for this work ($15,000) was made in March, 1873, and an additional appropriation of $5,000 was made in June, 1874.

On June 30, 1876, these appropriations had been nearly exhausted. On the Easton Bay side of the causeway, the channel had been completed; the width, however, having been reduced to 80 feet.

On the Chester River side the channel had been dredged to 80 feet in width over the entire distance, and an additional cut was being made, making the total width 100 feet as at first proposed. The passage through the causeway had also been cut to the full width allowed by the draw, 60 feet, and to a depth of fully 7½ feet.

Dredging was continued on the Chester River side of the causeway until July 7, 1876, when the work was closed, the appropriation having been exhausted. At this date the fifth cut had been carried about ¾ of the way from Chester River to the narrows, giving the full width of 100 feet over this portion of the channel.

Total amount of material removed since the commencement of operations in May, 1875, 99,747 cubic yards.

On the completion of operations a survey of the entire channel was made, occupying from the 10th to the 20th of July, and the soundings were afterwards carefully plotted. The soundings indicated a depth of fully 7 feet at ordinary low-water, through the entire length of the channel. Its width had also been well maintained. At the passage through the causeway, under the draw which had been built by the county authorities, a remarkable cutting was ascertained to have taken place, a depth of nearly 20 feet being found. The current through the passage was also very strong, after the epoch of high-water on the Easton Bay side, indicating the necessity of giving a greater vent to the water.

An appropriation of $5,000 was made for the work, by the act approved August 14, 1876; but of this amount only $1,000 became available for expenditure, notification of which was received September 15.

It was proposed with this amount to give at once an additional vent through the causeway, by cutting out from under the counterpoise of the draw, and to give further relief to navigation, by driving piles, forming wings on either side of the passage-way through the draw; but the severe storm of September 17–18, so completely broke up the entire causeway, that no expenditure on the part of the United States seemed to be justified, until such time as the authorities of the counties interested should have repaired the causeway and bridge.

On the 31st of March, the remaining $4,000 of the appropriation of August last was made available, but the condition of the causeway was still such that no expenditure on the part of the General Government could be recommended. Repairs upon the same by the county authorities were in progress, however.

In April last, an examination of the entire channel was made, occupying from the 18th to the 21st of the month, inclusive. It was found that the channel had maintained itself well, both as to width and depth. Some changes appeared to be taking place on the Easton Bay side, near the causeway, where it had been cut through, and in May a special examination was made at this point. It appeared to be quite evident that the water passing through the causeway was endeavoring to cut a new and more direct channel across the flat immediately below (Easton Bay side) the causeway, a new and deep pocket being found, extending in that direction from the passage. At an examination of the causeway and draw, in the early part of June, it was found that both had been put in better condition by the county authorities than heretofore, sufficiently good to seem to justify the General Government in going on with the improvement; and on June 4, a proposition was made to the Chief of Engineers to proceed with the work, and was by him approved.

The plan contemplated the expenditure of about $1,000 in cutting through the causeway under the counterpoise of the draw, in riprapping at the central pier and the counterpoise abutment, in driving piles to form wings at the passage through the draw, and in marking the sides of the channel with piles to serve the purpose of buoys, and to devote the balance of about $4,000 to cutting off several sharp turns in the channel, particularly in the immediate vicinity of the bridge on the Easton Bay side, all the materials to be purchased, as well as the machinery to be hired, in open market.

On June 11 operations under the above plan were commenced. During the month 18 guide-piles were driven on the port-side of the channel, marking thoroughly its entire length from Easton Bay to Chester River. These piles were stripped of bark and painted black.

Forty-two piles were driven at the passage through the causeway,

forming 4 wings, each 60 feet in length, and located, respectively, at each corner of the passage. These piles were planked up for a distance of 5 feet above high-water mark with 3-inch plank to protect the guards of passing steamers.

The causeway was cut out by hand to below low-water mark, and about 100 cubic perch of stone were used as riprapping at the central pier and at the counterpoise abutment. At the close of the above work, on June 28, a dredge and two scows were chartered by the day for the purpose of dredging at the sharp turns spoken of above.

The entire balance of funds on hand can and probably will be profitably expended in continuing this dredging.

The original estimate for this improvement was $23,000.

Twenty-five thousand dollars were appropriated in all up to June 30, 1877, but owing to long and unavoidable delays, and consequent increase of expenses, this sum has not quite completed the work estimated for. Occasional repairs will be required to keep this channel open when completed. Their cost will probably average $3,000 per year. This amount can be profitably expended in the fiscal year ending June 30, 1879.

Capt. C. B. Phillips, Corps of Engineers, has had the immediate supervision of this improvement.

This work is in the collection-district of Baltimore.

Money statement.

July 1, 1876, amount available	$5,374 15
Amount appropriated by act approved August 14, 1876	5,000 00
	10,374 15
July 1, 1877, amount expended during fiscal year	6,340 92
July 1, 1877, amount available	4,033 23
Amount (estimated) required for completion of existing project	3,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	3,000 00

F 2.

IMPROVEMENT OF THE ENTRANCE TO THE HARBOR OF BALTIMORE, MARYLAND.

The object of this work has been to secure by dredging such a channel as will enable vessels drawing 22½ or 23 feet to come to the city of Baltimore at any ordinary stage of the tide.

This object has been accomplished as regards depth, but additional width is needed.

When the work was practically complete, in 1874, it was estimated that an annual outlay of $50,000 would be required to maintain the channel in the condition in which it then was.

Since that date the appropriations for the work have exceeded the above estimate by but a small amount; but all the funds that could be spared for the purpose have been devoted to securing an additional width to the channels.

Thus, in the years ending June 30, 1875 and 1876, the Craighill channel was widened to 330 feet at those portions where it had a less width; the Brewerton Channel was widened by an additional cut 40 feet in width, making a total width of about 300 feet throughout; and the turning-place, at the junction of the Brewerton and Fort McHenry Channels, was enlarged. These increased widths have afforded some considerable relief to shipping, but more is needed.

The large steamers that ply to and from the port, and which have increased very rapidly of late, both in number and size, are very apt to

run against the sides of the channel, cutting off large slices of the bank, thus endangering the vessels and at the same time seriously injuring the channel.

During the past fiscal year operations have been confined to dredging at the upper end of the Fort McHenry Channel and the lower end of the Brewerton Channel. The object of dredging at the former point was to widen the entrance to the inner harbor of Baltimore to facilitate the passage in and out of large vessels.

At the latter point the object was to restore the original depth of the channel from the lower end to a point opposite to and a little above North Point. This portion of the channel necessarily projects into and across the current of the Susquehanna River, and has been referred to in previous annual reports as probably in need of more or less dredging each year in order that its depth may be maintained.

On June 30, 1876, the work remained suspended, and the Government tug Leslie was in charge of a watchman, the appropriation having been exhausted early in June.

By act of Congress approved August 14, 1876, an appropriation of $75,000 was made for the work; but no instructions as to its availability for expenditure were received until September 14, when an allotment of $40,000 was made.

The tug Leslie was at once put in commission, and examinations of portions of the channel commenced, to determine the points most in need of attention.

The examinations and the resulting maps having been completed, proposals for dredging were invited, and were opened November 1.

A contract was entered into with Messrs. Curtis, Fobes & Co., of Portland, Me., (the lowest bidders,) for the removal of 240,000 cubic yards of material, at the rate of 9¾ cents per yard. The contract required the work to be commenced December 1, 1876, and to be completed June 30, 1877. In December, while the contractors' machinery was on the way to Baltimore from the North, it was struck by a severe gale, and seriously crippled near Sandy Hook, N. Y.

The harbor of Baltimore, meanwhile, became closed with ice, and remained so until late in February, so that dredging would have been impossible had the apparatus been at hand.

Dredging at the upper end of the Fort McHenry Channel was finally commenced on the 7th of March, and was completed on the 2d of May.

The area dredged over consisted of two wedge-shaped pieces, one lying on the Lazaretto side, the other on the Fort McHenry side of the channel. This gives a much easier entrance to the inner harbor, the widening commencing at a point about 1,200 feet below the Lazaretto light, and attaining a width of 750 feet opposite said point. All this area was dredged to a depth of 25 feet at ordinary low-water; 94,000 cubic yards of material were removed from this locality. On the completion of this work dredging was commenced at the lower end of the Brewerton Channel. At the close of operations in June, 1876, an interior cut, 45 feet from the north side of the channel, had been carried up to nearly opposite North Point, and there left incomplete for want of funds.

During May and June, 1877, this cut was completed, and 3 additional interior cuts have also been made, completing the total of 240,000 yards called for in the contract.

All this dredging has been to 25 feet at ordinary low-water, and it leaves this portion of the channel, to the extent of five-sevenths of its width, in better condition than ever before.

The balance ($35,000) of the appropriation of August 14, 1876, having been rendered available in April last, a project of expenditure was sub-

mitted to the Chief of Engineers, which being approved, proposals were invited for dredging 300,000 cubic yards of material, in addition to the amount contracted for under the previous allotment. These proposals were opened on June 1, and a contract entered into with Mr. A. P. Brown, of Washington, D. C., (the lowest bidder,) for the execution of the work at the rate of 9¼ cents per cubic yard. The contract requires the work to be commenced July 1, 1877, and to be completed on June 30, 1878.

An examination of the lower end of the Brewerton Channel was made in May last, and the results plotted.

It disclosed the necessity of continuing the re-dredging over the remaining width of the Brewerton Channel, as far as opposite North Point; and also the necessity of enlarging the turning-place at its junction with the Craighill Channel.

It is proposed to complete the dredging at these two localities, and afterward to devote the balance available to dredging an entirely new cut through the Brewerton Channel, thus giving an additional width of 40 feet.

Quite extensive repairs to the tug Leslie will be required during the coming fiscal year, including the putting in of a new boiler, her present one being fifteen years old, and in very bad condition.

No appropriation was made for the coming fiscal year ending June 30, 1878. One hundred and thirty-five thousand dollars were asked for that year, which would have filled the estimated cost of the existing project, and provided for the annual reparations. To this sum add $50,000 for reparations, and we have as the amount that can be profitably expended in the fiscal year ending June 30, 1879, $185,000.

The immediate supervision of this work has been in the hands of Capt. C. B. Phillips, Corps of Engineers.

Money statement.

July 1, 1876, amount available	$794 68	
Amount appropriated by act approved August 14, 1876	75,000 00	
		$75,794 68
July 1, 1877, amount expended during fiscal year	20,265 72	
July 1, 1877, outstanding liabilities	9,497 05	
		29,762 77
July 1, 1877, amount available		46,031 91
Amount (estimated) required for completion of existing project		185,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		185,000 00

Patapsco River. Proposals for dredging. Bids opened at 12.5 *p. m. November* 1, 1876.

Number.	Name.	Residence.	Number of cubic yards bid for.	Price per cubic yard in Brewerton Channel.	Price per cubic yard in Fort McHenry Channel.	Price per cubic yard in Fort McHenry Channel deposited above Soller's Point.	Price per cubic yard in Fort McHenry Channel deposited 1 mile east of Craighill Channel.	Time. Commence—	Time. Complete—
1	Curtis, Fobes & Co.	Portland, Me.	All.	*$0 09¼	.....	....	$0 09¼	Dec. 1, 1876	June 30, 1877
2	James Cumings	New York	All.	15	.....	$0 19	24	Apr. 1, 1877	June 30, 1877
3	M. F. Brainard	Albany	80,000	....	.....	13	....	Dec. 10, 1876	June 30, 1877
4	W. H. Beard	Brooklyn	80,000	....	.....	17	....	Dec. 1, 1876	June 30, 1877
5	American Dredging Company.	Philadelphia	All.	17½	.....	20	25	Nov. 15, 1876	June 30, 1877
6	G. H. Ferris	Brooklyn	80,000	....	.....	11¼	....	Jan. 1, 1877	June 30, 1877

* 9¼ cents for all. Contract awarded.

Patapsco River. Bids for dredging opened at 12.5 p. m., June 1, 1877.

Number.	Name.	Residence.	Time. Commence—	Time. Complete—	Price per cubic yard.	Remarks.
					Cents.	
1	American Dredging Company.	Philadelphia......	June 15, 1877	June 30, 1878	13½	
2	Geo. C. Fobes & Co...	Baltimore.........	July 1, 1877	July 1, 1878	13	
3	Morris & Cumings Dredging Company.	New York City...	July 1, 1877	June 30, 1878	15	
4	A. P. Brown.........	Washington, D. C.	June 30, 1877	June 30, 1878	9¼	Contract awarded.
5	G. H. Ferris..........	Baltimore.........	June 15, 1877	July 30, 1878	12⅞	
6	M. F. Brainard.......	Albany...........	July 1, 1877	June 30, 1878	13¼	
7	Wm. H. Molthrop....	New London, Conn.	....	June 30, 1878	9¾	
8	E. R. Seward.........	Albany, N. Y......	June 15, 1877	June 30, 1878	15	

COMMERCIAL STATISTICS.

CUSTOM-HOUSE, COLLECTOR'S OFFICE,
Baltimore, Md., September 10, 1877.

SIR: In compliance with yours of the 4th instant, requesting a report relative to the commerce of Baltimore for the fiscal year just closed, the following exhibit is respectfully submitted:

In justice to my predecessor, I deem it proper to state that I took possession of this office on the 5th of July, so that it was impossible for him to furnish you with all of the information you asked for up to the end of the fiscal year.

Statements covering the last two years are generally given as affording a better view of the scope of the commerce of Baltimore, and as furnishing a better test of its capabilities for development and expansion.

DUTIES COLLECTED ON IMPORTED MERCHANDISE.

Fiscal year ending June 30, 1876, (coin)................................	$4,301,476 37
Fiscal year ending June 30, 1877, (coin)................................	3,522,215 81

RECEIPTS FOR TONNAGE, STEAMBOAT INSPECTIONS, LICENSES TO PILOTS AND ENGINEERS, CUSTOMS-FEES, ETC.

Fiscal year ending June 30, 1876, (currency)...........................	$158,541 87
Fiscal year ending June 30, 1877, (currency)...........................	183,868 70

The above showing of duties is not to be taken as a fair indication either as to the extent of the commerce of Baltimore, in dutiable commodities, or as to the measure of its resources and facilities as a commercial city. This view will become apparent in the progress of this statement, and is already sustained in the fact of increase in the currency receipts, which is an evidence of improvement in the foreign trade.

Passing over the fact of the unusual depression of trade, and also the fact that home industries are supplanting foreign ones with the products, which everywhere alike have diminished importations, there have been, however, causes of a kindred nature, exceptional in the case of this port, because of their effects upon its commerce, which should be mentioned in this connection.

This statement will show that among the chief articles of dutiable imports at Baltimore was that of sugar. That trade in its various branches is very extensive, and necessarily identifies itself with many other interests. During the last five years the two several failures occurred here of leading houses which gave that interest a serious shock and set-back. The more recent failure visibly affected the sugar trade, and in a very palpable sense lessened, for a time, the importation of that article.

That failure carried down an establishment that had well-nigh amounted to a monopoly of that trade, especially in the sugar-refinery branch, having under its control four at least of the principal refineries in the city of very large capacity. Its failure, consequently, amounted almost to a paralysis in effect upon the sugar trade, and impinged many kindred interests.

The decline in duties during a portion of the last year, as presented in the above exhibit, is almost wholly due to that disaster.

As an evidence, however, that it caused no impairment of the native vigor of the commerce of the port, or its ability to recuperate after disaster, a contrast is drawn between the revenue receipts for the last three months of the closing fiscal year and those

of the same months of the one preceding, in which it will be seen that the increase has been very manifest, indicating a marked revival in the foreign trade of this port in dutiable commodities.

April, 1876	$207,960 15	April, 1877	$461,376 17
May, 1876	197,169 64	May, 1877	446,083 41
June, 1876	242,324 22	June, 1877	404,039 00
	647,454 01		1,311,498 58
			647,454 01
Increase over last fiscal year for that period			664,044 57

As a further reason that the duties above given do not show the extent of the foreign trade here in importation, it may be stated that merchants in many instances import goods through other cities. That portion of the trade so diverted through other channels will, in time, as facilities improve, stay at home, and go direct from this port.

Again, this port is the gateway or entrepot of the great West and other sections of the country. Importations of goods are made through Baltimore for other places by transportation in bond without appraisement, without breaking bulk, "transportation with appraisement," besides withdrawals from bond, which merchandise goes to other ports of entry and delivery, at which places the duties are paid.

The value of goods transported in bond, without appraisement, and the duties collected thereon, are as follows:

Fiscal year 1877: Value, $219,077; duties, $71,417.34.

Transported in bond with appraisement for fiscal year closing June 30, 1877: Value, $504,182; duties, $193,550.52.

The destinations of goods so imported are mainly for the West, as already stated, but in some instances they go to Boston and Philadelphia, and occasionally New York.

The character of goods so imported compose the following varieties in part: hardware, toys, perfumery, manufactures of cotton, wool, metals, steel, glass, &c., leather, drugs, tin-plates, wines, liquors, champagne, ginger ale, cutlery, medicines, potash, and soda-ash, sugar, salt, soaps, brushes, silks and clothing, china, earthenware, woolen goods, &c.

In addition to the importations made in the manner mentioned, large quantities of goods are entered for warehouse, upon which the duties are paid upon withdrawal. This may not take place within the year, and in some cases runs to the limit of three years. The value and duties of goods so entered for the fiscal year just closing are as follows:

	Value.	Duty.
Goods imported in American vessels	$2,931,900	$1,408,411 97
Goods imported in foreign vessels	3,010,096	1,443,376 07
Total	5,941,996	2,851,788 04

The commodities so imported consist of a similar variety to those above mentioned, those of chief value being sugar, molasses, melada, salt, jute bagging, hessians, wines, champagnes, sodas, iron, tin, lead, metal, steel, glass, glassware, carpets, toys, woolens, silks, linen, preserved fruits, china and earthenware, drugs, dyes, &c.

The above showing relates wholly to dutiable merchandise imported, and of course does not show the extent or value of foreign importations; other commodities, upon which there are no duties, are largely imported into this port, especially the article of coffee, which comprises here a large and valuable trade, the importance of which is scarcely less than any city of the Union, if it is not destined to equal all others. This article is heavily marketed in the West. The value of foreign importations, dutiable and undutiable, for the fiscal year closing June 30, 1877, amounts to the sum of $22,025,641.

The value of imports for the preceding year amounted to the sum of $22,340,629.

It will be perceived from the above comparisons that the value of importations for the last year is eqal within a trifle to that of the preceding year, notwithstanding the untoward causes referred to that have militated against the commerce of the port.

A comparison of imported values between the six months of the year just closed and that of the preceding year, exhibits a vigorous revival of foreign trade, and sustains the views expressed in the first part of this communication.

Value of imports from January, 1876, to June, 1876, (inclusive)	$9,468,646
January, 1877, to June, 1877	13,881,922
Increase over six months of previous year	4,413,276

This exhibit affords a rate of increase amounting annually to over $8,000,000 in the

value of foreign imports. Among the articles imported of chief value for the year mentioned are as follows:

	Value.
Sugar, molasses, and melada	$6,365,908
Coffee	11,144,506
Tin-plates	1,078,846
Sodas	448,755
Guano	196,916
Hides	184,422
Salt	129,835
Sulphur	105,175

Besides which, rating next in value, are cloths, cassimeres, dry goods, woolens, silks, dress goods, carpets, fruits, drugs, wines, champagne, &c.

The articles of steel rails, manufactures of steel and hardware, were heretofore among the importations of chief value. But during the last year no rails have been imported, and but limited quantities of the latter articles mentioned. This is due, doubtless, in a great measure, to the completion of railroads, and to the fact that home industries in the manufacture of steel and hardware are occupying the home market and infringing upon the foreign market.

The other branch of foreign commerce relates to domestic exports. The growth in this particular has been most marked and perspicuous.

At the close of the fiscal year ending June 30, 1871, the value of domestic foreign exports was $15,037,855. At close of fiscal year 1876, five years thereafter, those exports amounted to $31,216,870, more than duplicated. For the fiscal year closing June, 1877, the value of foreign exports amounts to $40,000,000, nearly double the value of imports.

The commodities exported and their values, with the exception of a few articles, exported in limited quantities, are given in the following table:

Acids		$5,124 00
Agricultural implements		2,475 00
Animals living, hogs, horses, mules, sheep, &c		13,959 00
Bark for tanning		38,068 00
Blacking		691 00
Bread and breadstuffs:		
Bread and biscuit	$40,606 00	
Indian corn	12,961,689 00	
Indian-corn meal	105,782 00	
Oats	11,691 00	
Rye	41,855 00	
Rye-flour	279 00	
Wheat	2,035,315 00	
Wheat-flour	2,641,421 00	
Other small grains	5,389 00	
Maizena, farina, &c	14,185 00	
		17,858,212 00
Brooms, brushes, &c		6,862 00
Candles, tallow, &c		22,326 00
Carriages, carts, &c		4,360 00
Coal		76,479 00
Copper and manufactures of copper, ore		3,700 00
Copper in pigs, bars, sheets, &c		17,262 00
Cordage, rope, twine, &c		7,874 00
Cotton and manufacture of:		
Sea island	$232,613 00	
Other manufactured	1,747,227 00	
Colored	19,538 00	
Uncolored	66,644 00	
All other manufactures of	1,801 00	
		2,067,823 00
Drugs, chemicals, medicines		33,167 00
Dye stuffs		10,489 00
Fruits:		
Apples, dried	156,313 00	
Apples, green or ripe	3,276 00	
Other fruit, ripe	1,429 00	
Preserved in cans or otherwise	30,764 00	
		191,782 00
Furs and fur skins		16,300 00
Glass and glassware		17,211 00

Gold and silver and manufacture of:		
Silver coin	$65,000 00	
Jewelry	129 00	
		$65,129 00
Hair, manufactured		92,860 00
Hay		2,424 00
Hemp and manufactures of		2,395 00
Hides		7,016 00
Hoops		73,441 00
Iron and steel manufactures:		
Cutlery, machinery, boilers, edge-tools, files, saws, &c.; steel manufactures, guns, &c		28,882 00
Lamps		3,771 00
Lead manufactures		1,174 00
Leather manufactures:		
Boots and shoes	6,120 00	
Morocco, saddlery, &c	205,478 00	
		211,598 00
Marble and manufacture of		541 00
Matches		1,458 00
Pianos and musical instruments		883 00
Rosin, turpentine, tar, and pitch		14,035 00
Oil-cake		146,077 00
Oils:		
Mineral, crude	171,200 00	
Mineral, refined or manufactured, naphtha, (benzine, gasoline)	64,224 00	
Illuminating	7,472,446 00	
Lubricating	41,421 00	
Residuum, tar, pitch, &c	6,122 00	
Animal oils:		
Lard oil neat's-foot oil, sperm, &c	11,342 00	
Vegetable oils:		
Cotton-seed	37,197 00	
Linseed	551 00	
Volatile	364 00	
		7,804,867 00
Paints, colors, paintings, and engravings		1,279 00
Paper and stationery		15,585 00
Provisions:		
Bacon and hams	699,493 00	
Beef	162,310 00	
Butter	18,773 00	
Cheese	11,306 00	
Condensed milk	1,325 00	
Fish, dried or smoked	1,395 00	
Fish, pickled	4,745 00	
Fish, cured	31,521 00	
Lard	1,355,090 00	
Meats, preserved	22,641 00	
Oysters, pickles, and sauces	27,467 00	
Pork	371,276 00	
Onions	514 00	
Potatoes	7,884 00	
Vegetables and vegetables preserved	12,970 00	
		2,728,710 00
Quicksilver		2,000 00
Rice		31,424 00
Scales		547 00
Seeds—cotton, flax-seed, clover, timothy, &c		397,423 00
Sewing-machines		1,087 00
Soap, perfumed toilet, &c		12,979 00
Distilled spirits		2,426 00
Spirits turpentine		538 00
Starch		64,280 00
Sugar and molasses:		
Refined	43,660 00	
Candy and confectionery	1,163 00	
		44,823 00
Tallow		133,972 00

Tin and manufactures of	$18,920 00
Leaf and manufactured tobacco	6,446,589 00
Trunks, valises, umbrellas, parasols, &c	3,865 00
Vessels sold to foreigners	9,500 00
Vinegar	107 00
Wax	2,236 00
Wearing apparel	2,472 00
Wood and manufactures of wood:	
Boards, clapboards, planks, joints, &c	69,559 00
Shingles	9,844 00
Shooks, staves, hogsheads, barrels, &c	210,831 00
Poles, masts, spars, &c	148,336 00
Household furniture	9,407 00
Articles of wood manufactured and unmanufactured	27,546 00
Articles not enumerated, manufactured and unmanufactured	49,012 00

The extent and value of the coastwise trade in domestic traffic may only be conjectured, as the much larger portion of it forms no part of the records of this office; but in view of the extensive inland water-communication of this port, and its intimate business relations with ports on the Atlantic seaboard and elsewhere, that branch of domestic trade in quantity and value is very considerable.

It may be remarked in this connection that exportation of articles of domestic industries are made in some instances through other ports, and therefore do not appear in the statistics of this office. There are a number of extensive cotton and other mills within the environs of Baltimore. The manufacture of cotton duck has become an extensive and valuable interest. Manufacturers say that three-fourths of it is turned out at these mills around Baltimore, much of which is exported as mentioned. In time these exportations and others will go direct from this port. The next feature of this statement will relate to navigation, vessels, tonnage, &c.

COASTWISE ARRIVALS, STEAMERS, PROPELLERS, SCHOONERS, BARKS, SHIPS, BRIGS, ETC.

For the fiscal year 1876: Number of vessels, 1,626; tonnage in amount, 1,238,942.
For the fiscal year 1877: Number of vessels, 1,732; tonnage in amount, 1,213,156.

The harbor was closed by ice during the winter months, which effectually stopped navigation, especially that of a local character, which fact is very apparent in the records of arrivals during those months, and also of clearances; an increase, however, of over one hundred appears in arrivals, and an excess of about twenty in clearances.

COASTWISE CLEARANCES.

Fiscal year 1876: Vessels, 1,993; tonnage, 1,342,157.
Fiscal year 1877: Vessels, 2,014; tonnage, 1,249,833.

American vessels arriving from foreign ports:
Fiscal year 1876: Vessels, 306; tonnage, 100,450.
Fiscal year 1877: Vessels, 352; tonnage, 122,590.

Foreign vessels arriving from foreign ports:
Fiscal year 1876: Vessels, 793; tonnage, 572,206.
Fiscal year 1877: Vessels, 1,144; tonnage, 798,541.

American vessels cleared for foreign countries:
Fiscal year 1876: Vessels, 294; tonnage, 86,788.
Fiscal year 1877: Vessels, 254; tonnage, 87,993.

Foreign vessels cleared for foreign countries:
Fiscal year 1876: Vessels, 817; tonnage, 587,282.
Fiscal year 1877: Vessels, 1,046; tonnage, 752,512.

Total number of vessels and tonnage arriving from foreign countries for the fiscal year 1876: Vessels, 1,496; tonnage, 921,131.

Total number of same clearing, &c.: Vessels, 1,300; tonnage, 839,505.

Total amount of tonnage entering and departing the barbor of this port for the fiscal year, as per record:

	Tons.
Fiscal year 1876	1,688,883
Fiscal year 1877	3,011,469
Increase	1,322,586

This exhibit shows a marked improvement in arrivals and clearances. Independently of the above, many vessels enter and leave the port which, under the navigation laws, are not required to report at the custom-house. The tonnage of this class of

vessels, if it could be known, would doubtless exceed the amount urnished by the records of this office.

The registered outstanding tonnage of this district—

FISCAL YEAR 1876.

	No.	Tonnage.
Permanent registered sail-vessels	69	22,878.56
Permanent enrolled sail-vessels	518	24,017.15
Permanent licensed sail-vessels	177	2,202.56
		49,098.27
Permanent enrolled steam-vessels, wood	75	25,594.73
Permanent enrolled steam-vessels, iron	20	9,313.67
Permanent licensed steam-vessels, wood	14	173.97
Temporary registered sail-vessels	30	11,005.95
Temporary enrolled sail-vessels	29	6,388.16
Temporary registered steam-vessels	3	351.41
Temporary enrolled steam-vessels	1	368.95
Total	936	102,295.11

FISCAL YEAR 1877.

	No.	Tonnage.
Permanent registered sail-vessels	65	21,661.82
Permanent enrolled sail-vessels	553	25,306.30
Permanent licensed sail-vessels	190	2,422.26
Permanent enrolled steam-vessels, wood	79	25,098.57
Permanent enrolled steam-vessels, iron	22	10,084.15
Permanent licensed steam-vessels, wood	13	165.80
Permanent enrolled barge, wood	1	31.49
Temporary registered sail-vessels	19	8,672.12
Temporary enrolled sail-vessels	51	13,332.73
Temporary registered steam-vessels	1	122.47
Temporary enrolled steam-vessels	1	163.79
Total	995	107,061.50

INCREASE OVER LAST YEAR.

Heretofore the canal-boat tonnage comprised part of the registered tonnage of the district, and amounted to 555 boats, and the following tonnage, 32,888.47. This class of vessels is not now required to be enrolled and licensed, as formerly. This exemption caused, of course, some shrinkage in the aggregate tonnage of the port. It will appear, by comparison of the last ten years, that there has been an increase in the tonnage evidently of a class of vessels that shows growing strength and expansion in the commercial marine of the port.

Tonnage receipts, fiscal year 1876	$71,350 54
Tonnage receipts, fiscal year 1877	98,015 70
Increase	26,665 16

The above increase is attributable to the marked additional foreign arrivals.

Before mentioning the several foreign lines of steamers, together with the sea-coast and inland lines, it will be in place at this point to refer to the arrival of passengers at this port.

For the year ending March 31, 1877, the following passengers arrived:

	Males.	Females.	Total.
Immigrants	2,586	2,154	4,740
Passengers not immigrants	504	273	777
	3,090	2,427	5,517
Cabin-passengers	421	207	628

At this port there are four foreign lines of steamships, besides which there are incidental arrivals from other lines which may become regular ones.

The North German Lloyd line comprises several magnificent iron mail-steamships of an average tonnage each of 3,000 tons, and was established as a line at this port in 1868. This line runs between Baltimore, Southampton, and Bremen, communicating with Havre, London, and Paris. The Allan line comprises a similar class of iron mail-steam-

ships, averaging over 3,000 tons burden, and this line runs between Baltimore and Liverpool, via Halifax and intermediate places; was established in 1870. The piers of those lines are the terminus of the Baltimore and Ohio Railroad, at which place freight is landed and received either from or directly to the West, according to destination.

There are two Spanish lines combined in one, comprising 15 first-class iron steamships, averaging 2,800 tons burden, established in 1874, running between Baltimore and Liverpool, via Havana, and the British Beaver line, of three first-class steamship and several first-class iron clipper-ships, with an average tonnage of 3,000 tons, established in 1875. Those two last-named lines maintain an average arrival of one steamer per week.

The vessels last mentioned require a depth of water averaging 24 feet.

The sea-going coastwise line of steamers are the Boston line, comprising eight or ten splendid steamers, of an average capacity of 2,000 tons, the Savannah, Charleston, Wilmington, New Berne, Norfolk, York River, James River, Rappahannock, Potomac to Washington, Alexandria, and Georgetown, and a line to Philadelphia and New York, by way of canal, besides the many local lines touching at places on the Chesapeake Bay and its tributaries within the State and adjacent thereto.

The above exhibit expresses of itself sufficiently clearly the commercial value of the harbor of Baltimore, both locally and nationally, without any comment.

It certainly affords an evidence of a substantial and enduring commercial basis, both intrinsic and acquired, that must enlarge and expand in the near future to limits of greater value. The locality of this port, its advantageous surroundings, and its short lines of inland communications with the West and Mississippi Valley, indicate its immediate and also its growing importance.

Two of the great leading railroads of the country find a terminus in Baltimore upon valuable water-fronts, both of which are competing carriers for the treasures of the West, naturally flowing to Baltimore; indeed, new enterprises are now in contemplation, among which may be mentioned that of the exportation of fresh meat, and that of increased facilities for the transportation of mineral oils to this port.

And while its local interests are necessarily chief considerations to its citizens, nevertheless its relations identify it intimately with sea-ports of the Atlantic coast north and south, and also with the vast producing areas of the interior, and render its importance in a national sense alike of interest to the whole country.

The improvement and efficient maintenance of its harbor, nationally considered, are of permanent importance.

By a short cut across the eastern peninsula of the State, the Chesapeake and Delaware Bays can be united. This is a practical project, and although the Government may not deem itself justified in undertaking the outlay for a ship-canal to unite the two bays, yet the project is so tempting and feasible that local capital, with that of adjoining States, will be induced at no distant day to undertake and complete the enterprise. Then the Government would have an inland water communication from Philadelphia to the Carolinas, which in the event of hostilities would be of vast advantage, and in no less a sense would it confer a valuable benefit upon the commercial marine of the Atlantic and southern coasts.

I am, very respectfully, your obedient servant,

JOHN L. THOMAS, JR.,
Collector.

Maj. W. P. CRAIGHILL,
Corps of Engineers, U. S. A.

F 3.

IMPROVEMENT OF THE WICOMICO RIVER, NEAR SALISBURY, MARYLAND.

The original plan of improvement for this locality was to secure, by dredging, a channel 75 feet in width and 7 feet in depth at ordinary low-water from the bridge at Salisbury to the deep water of the bay below, a distance of about 7,000 feet, the removed material to be deposited behind longitudinal dikes.

Owing to insufficient means, and the failure of the property-owners to fully carry out their promises in regard to assisting in the construction of the diking, it was found to be impossible to execute the above project, and the plan was so modified as to contemplate the dredging of a channel only 50 feet in width and 5 feet in depth at ordinary low-water, the greater portion of the expense of diking falling upon the Government.

As stated in the last annual report, work was discontinued on January 7, 1876, the appropriation having been exhausted. At this date the channel, as per modified plan, was completed, except for a distance of about 300 feet, which was made only 28 feet in width, on account of lack of funds.

Work has remained suspended during the whole of the past fiscal year.

By act of Congress approved August 14, 1876, an appropriation of $5,000 was made for this work; but in pursuance of instructions from the War Department it remained unavailable for expenditure until March 31, 1877.

The appropriation having become available on this date, a re-examination of the entire channel and dikes was made as soon as possible, with a view to submitting a project for its expenditure. This re-examination was made during the early part of May, occupying from the 3d to the 11th of the month. The soundings were immediately plotted. It was found that the channel had stood quite well, both as to width and depth, from the bay up to the wharves near the town, a depth of fully 5 feet at ordinary low-water being found over the entire distance. Along the wharves, and at the turning-basin near the iron bridge, it had filled in very badly, a depth of only 2 feet at ordinary low-water being found at some places. This filling appears to be due in a great measure to the inflow of sawdust from the mills above. The dikes were found to have remained in very good condition.

On the 14th of May last a proposition to proceed with the work was submitted to the Chief of Engineers, and was by him approved. Arrangements have been made for recommencing work, which will consist simply in dredging. It is estimated that the amount of funds now available will be sufficient to widen the channel to 70 feet through its entire length, retaining the present depth of 5 feet at ordinary low-water, and to redredge the turning-basin and in front of the wharves. It may not be deemed expedient to redredge at these latter localities, unless assurances are received from the proprietors of the saw-mills that no more sawdust will be allowed to flow into the stream.

It is expected that these dredging operations will be commenced early in July, the contractor for the work being now engaged in fitting up his machinery.

It is estimated that from three to four months will be required to execute the work contemplated.

The appropriations have been June 10, 1872; March 3, 1873; June 23, 1874; March 3, 1875, and August 14, 1876. Total, $25,000.

No appropriation was made for the fiscal year ending June 30, 1878.

Should the original plan be carried out, an appropriation of $15,000 will still be required. The work has been under the immediate supervision of Capt. C. B. Phillips, Corps of Engineers.

This improvement is in the collection-district of Baltimore.

Money statement.

July 1, 1876, amount available	$71 04
Amount appropriated by act approved August 14, 1876	5,000 00
	5,071 04
July 1, 1877, amount expended during fiscal year	370 34
July 1, 1877, amount available	4,700 70
Amount (estimated) required for completion of existing project	15,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	7,500 00

COMMERCIAL STATISTICS.

SALISBURY, MD., *June* 12, 1877.

SIR: Referring to your request, I have the honor to submit the following statement of the business of Salisbury for the past year, carried on principally by vessels navigating Wicomico River.

Within the town are three water and four steam saw-mills, one water and two steam planing-mills, two large grist-mills, one kindling-wood factory, one carriage-factory, one hub-mill, one carding-mill.

Shipments for the year have been 9,900,000 feet of rough lumber, 2,200,000 feet of dressed flooring, 820,000 peach-crates, 250,000 oil-can cases, 75,000 canned-fruit cases, 5,000 strawberry-crates, 7,200 cords cord-wood, 3,000 railroad ties, 301,000 quarts strawberries, 11,000 watermelons, 4,000 barrels truck and vegetables, 58,000 quarts wild berries, (25,000 crates peaches will be shipped this season,) 41 carriages, 10,000 hubs, 13,000 pounds corded wood, 57,000 bushels grain, 13,000 bushels corn-meal, 1,520 barrels flour, and 11,300 pounds flour in quantities less than one barrel.

Sales other than shipments enumerated have been $616,000 of general merchandise, 1,409 tons coal, 140 tons fertilizers, 57,000 bushels oyster-shells, 28,000 bushels oysters.

There are 38 stores in the town. Fifteen schooners of 913 tons, (registered tonnage,) and 54 smaller boats, trade from our wharves. Very low prices of produce have decreased our annual production and sales.

Very respectfully,

GEO. W. PARSONS.

Col. W. P. CRAIGHILL,
Major Corps of Engineers, U. S. A.

F 4.

IMPROVEMENT OF THE JAMES RIVER, VIRGINIA.

For want of funds, work on this improvement was suspended on the part of the United States in March, 1876, and not resumed until the middle of September, 1876, when a portion ($40,000) of the appropriation of August 14, 1876, ($60,000,) became available. Work was not resumed by the city of Richmond until March 1, 1877. Mr. H. D. Whitcomb has continued to be the resident engineer for the United States at Richmond, while at the same time engineer for the city in the joint operations for this improvement. Of the machinery used, that portion for blasting and removing rock belongs to the United States; the remaining machinery, which has been employed during the year, belongs to the city of Richmond. It has been rented to the United States for actual cost of repairs while in its service. The operations have been chiefly confined to the channel from the Brewery to Almond Creek, and the channel through Goode's Rocks, of which the former has received a width of 100 feet and a depth of 15 feet at mean low-water, and the latter an equal width with a depth of 13 feet, much the larger portion being 15 feet. Wing-dams have been also used to a limited extent at the bars near the city, for the purpose of contracting the width of the river to about 600 feet. The results thus far are satisfactory, showing an increased depth. Mr. Whitcomb estimates that it requires now the removal of but 28,000 cubic yards of sand and gravel to give a channel 100 feet wide and 12½ feet deep at mean low-water from Rocketts Reef to Hampton Roads, which is equivalent to 16 feet at high-water.

The operations of the year have very manifestly ameliorated the navigation of the river; vessels in greater numbers and heavier draught now coming to the wharves of Richmond, especially those of the Chesapeake and Ohio Railroad. But a greater width and depth of channel are requisite, viz, of 15 feet at low-water, with a width of 180 feet, as stated in previous annual reports.

Meager appropriations, and the consequent protraction of the operations over a longer time, necessarily entail increased expense.

The estimate of 1874 was	$408,925 00
The appropriations since have been, June 23, 1874, $50,000; March 3, 1875, $50,000; August 14, 1876, $60,000; total	160,000 00
Leaving to be provided	248,925 00

Mr. Whitcomb's revised estimate is now somewhat greater, viz, $258,024.

Money statement.

July 1, 1876, amount available	$104 59
Amount appropriated by act approved August 14, 1876	60,000 00
	60,104 59
July 1, 1877, amount expended during fiscal year	43,201 67
July 1, 1877, amount available	16,902 92
Amount (estimated) required for completion of existing project	258,024 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	150,000 00

REPORT OF MR. H. D. WHITCOMB, ASSISTANT ENGINEER.

RICHMOND, *June* 1, 1877.

COLONEL: I have the honor to submit the following report on the improvement of James River from July 1, 1876, to May 31, 1877, inclusive. All work on the improvement was suspended July 1, 1876, that by the United States having ceased in March.

Work was resumed by the United States September 15, 1876, and by the city of Richmond March 1, 1877, and has been carried on by both parties to the present date, a period of eight and one-half months.

No contracts have been made except for the supply of timber; the work has been done by the day both by the United States and by the city. On the 15th September, 1876, two dredges began work on the widening and extension of the channel between the Brewery and Almond Creek. On 1st October a third dredge and the machinery for blasting and removing rock began work on the Goode's Rock Channel, and work was commenced on the timber-groins intended to contract the width of the river on Richmond Bar. Of the machinery used the United States owns that for blasting and removing rock, including one lighter; the remaining machinery, consisting of two steam-tugs, three dredges, one powder pile-driver, two steam-dumpers, and nine lighters, belongs to the city of Richmond, and is rented to the United States for actual cost of repairs while in its service.

AMOUNT OF WORK DONE.

The following statement gives the cubic yards of material removed by dredging and blasting since September 15, 1876:

	By the United States.		By Richmond City.	
	Cubic yards earth, &c.	Cubic yards rock.	Cubic yards earth, &c.	Cubic yards rock.
Channel between Brewery and Almond Creek	26,655	140.25	13,216	10.50
Channel through Goode's Rocks	3,101	1,267.42		
Lump in Dutch-Gap Canal	32			
Total	29,788	1,407.67	13,216	10.50

By the James River and Kanawha Canal Company, at entrance to dock, sand ..... 6,240 cubic yards.
By the Old Dominion Steamship Company, at their wharf, sand ..... 2,816 cubic yards.
By the Old Dominion Steamship Company, at their wharf, bowlders. 3 cubic yards

By all parties:

Earth, sand, decomposed rock, cobble-stones, and small bowlders	52,060	cubic yards.
Solid rock and large bowlders	1,421.17	cubic yards.
Total	53,481.17	cubic yards.
Timber-groins built	3,863	feet.

The cost of that portion of the work done by the United States, including repairs and renewals, and detentions, and damages by freshets or accidents, but not including interest on capital invested in machinery, has been as follows:

Material dredged below Brewery, decomposed rock, cobble-stones, and sand, including transportation to and dumping on groins, per cubic yard	$0 33.53
Cobble-stones, small bowlders, decomposed rock, &c., dredged at Goode's Rock	1 39.23
Solid rock and large bowlders blasted and raised	7 54.10
Timber-groins, materials, work, and repairs, per linear foot	1 46.25

Of the amount excavated, 36,168 cubic yards was transported to and dumped on the groins or training-walls by the United States, and the remainder similarly disposed of by other parties.

The channel from the Brewery to Almond Creek has been excavated 100 feet wide and to a depth of 15 feet at mean low-tide. The channel through Goode's Rocks has been excavated 100 feet wide and to a depth of 13 feet at low-tide; much the larger portion being 15 feet.

The wing-dams and training-walls have widened the navigable channel, and, in most cases, deepened it; and it now requires the removal of only 28,000 cubic yards of sand and gravel to open a channel 100 feet wide and 12½ feet deep at mean low-tide from Rocketts Reef to Hampton Roads. This is equivalent to 16 feet at mean high-tide.

The Dutch-Gap Canal is now used by all classes of vessels coming to this port, but needs further widening to be entirely satisfactory.

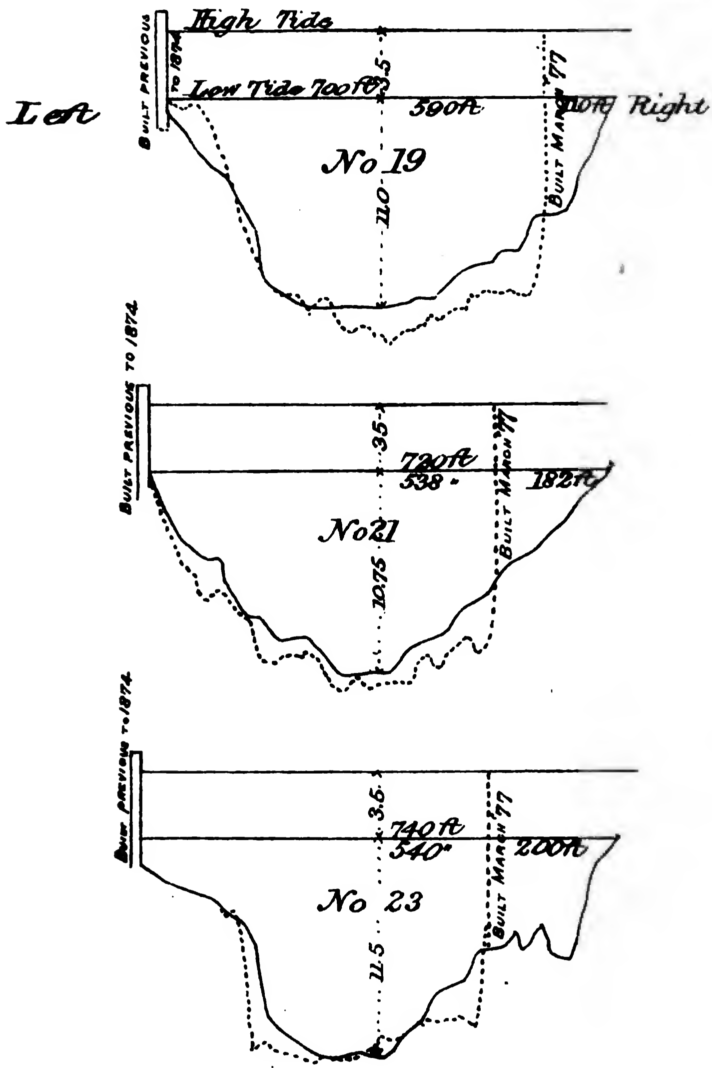
In the last annual report an analysis of the survey of 1874 was given, which indicated that many of the shoals on the river could be permanently removed by contracting the width of the river at certain points; and the opinion was expressed that the width on Richmond Bar should be from 550 to 600 feet. The experiment of contraction has been tried in an incomplete way, for the appropriation did not permit the full execution of the plan. Timber-groins or wing-dams have been built from 400 to 1,200 feet apart on Richmond Bar and other shoals, and in this way the river has been contracted in width to about 600 feet so far as they extend. The results are shown in the accompanying table and diagrams. The first groin, which contracted the river-width to about 600 feet, was built with your approval by the city in June, 1876, and is numbered 35 in the table. The remainder were built by the United States between October, 1876, and March, 1877. The scour observed, due to the tides, which here have a range of 3½ feet, has been very small, and freshets in the river must be relied on for rapid effects. There has been no considerable freshet during the year. The highest rise noted occurred September 24, 1876, and was 8.69 feet above mean high-tide. Another occurred in January, accompanied with an unusual quantity of ice, of 7 feet; a third in May was 2.55 feet. Each of these freshets improved the channel opposite to and between the wing-dams to such an extent as to warrant the expectation that the improvement will continue in the future, *and will probably be permanent.*

Sections 19. 20. and 21. 8700 to 9600 ft. below Dock

Full Lines Contours of Jan. 1874

Broken . " " May 1877

Hor: Scale 300 ft and Vert. Scale 10 ft to the Inch



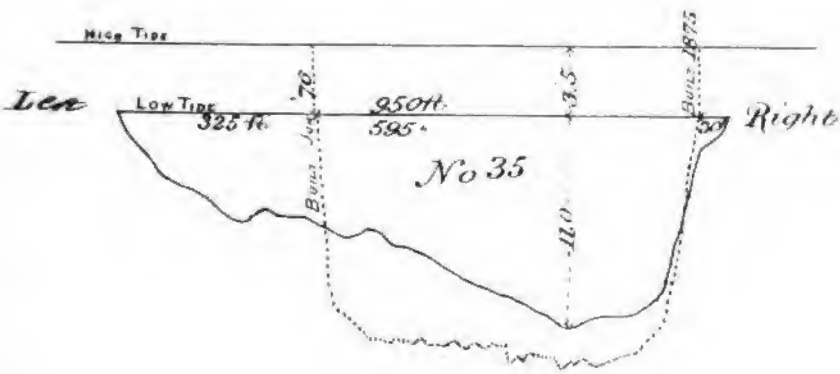
Sections 35. 37. 39. 41 and 43

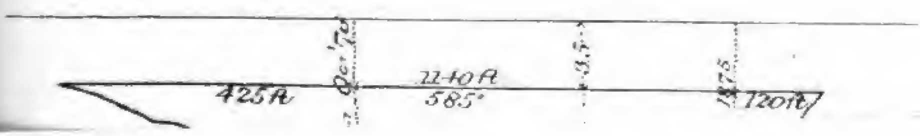
Richmond Bar 14500 to 16300 ft below Dock

Full Lines contours of Jan. 1874

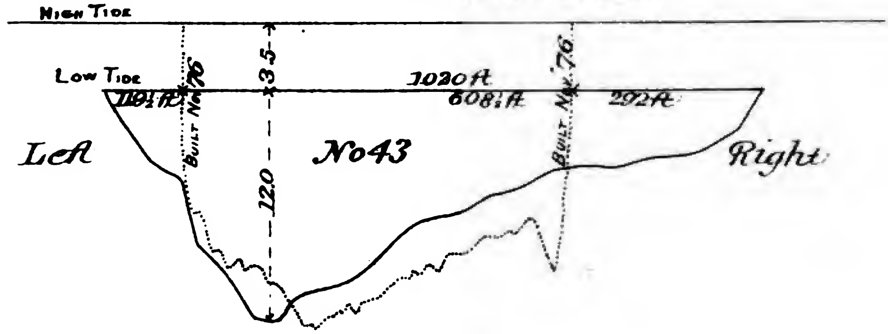
Broken do do May 1877

Scales 300 ft Hor and 10 ft Vert to 1 Inch

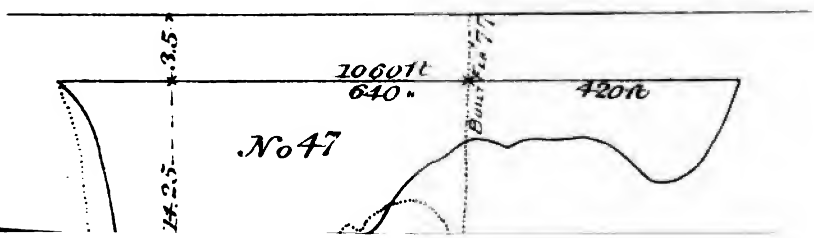




Full Lines contours of Jan 1874
Broken do do May 1877
Scales 300 ft Hor. and 10ft Vert. to 1 in.



Section 47 17500 ft below Dock



Statement giving the characteristics of certain sections of James River in 1874 and 1877, showing the effect of contracting its width in the interval up to May, 1877.

Number of plan.	Width at low-tide, in feet, 1874.	Area at low-tide, in square feet, 1874.	Best channel depth at low tide for 100 feet width, 1874.	Present width at low tide, in feet.	Date when the contraction was completed.	Square feet cut off by wing-dams.	Area of section at low-tide, in square feet, May, 1877.	Area scoured, square feet.	Best channel-depth at low-tide for 100 feet width, 1877.	Time elapsed since contraction was completed.
19	700	5,354	11.0	590	March, 1877....	464	5,336	446	12.2	2 months.
21	720	4,729	10.5	538	March, 1877....	568	4,718	557	10.8	2 months.
23	740	4,913	11.3	540	March, 1877....	934	4,426	447	11.4	2 months.
35	950	6,298	10.3	595	June, 1876......	1,422	6,559	1,703	12.5	11 months.
37	1,140	5,504	8.7	585	Oct., 1876	1,588	6,008	2,092	11.8	7 months.
39	1,205	5,799	8.0	598	Oct., 1876	1,845	5,843	1,889	10.8	7 months.
41	1,140	5,552	9.3	600	Nov., 1876......	1,245	5,497	1,190	10.8	6 months.
43	1,030	6,201	12.2	608	Nov., 1876......	1,295	5,598	690	11.4	6 months.
47	1,060	7,284	12.3	640	Feb., 1877......	1,723	5,973	412	12.8	3 months.
51	1,020	6,481	9.0	637	Dec., 1876......	1,539	6,414	1,472	11.2	5 months.
53	990	6,783	9.3	637	Dec., 1876......	1,234	6,329	780	11.6	5 months.

For further information on these sections, see diagrams.

If these sections are a fair representation of the bottom between them, the number of cubic yards removed by scour is as follows:

Between 19 and 23	15,238
Between 35 and 43, Richmond bar..	129,937
Between 43 and 47	25,017
Between 47 and 51	33,496
Between 51 and 53, Randolph flats	20,826
Total cubic yards	224,514

There has been some shoaling below the lowest groin built, where the width is abruptly increased from 637 feet to about 800 feet. On the opposite side to the groins there is a timber training-wall, built in 1874–'75, which had contracted the width to about 800 feet, and had caused considerable scour. The present depth is greater than it was in 1874, but it is less than it was in 1876, but is still equal to 14½ feet at mean high-tide.

Obviously, the contraction of the river should be continued down to a point where its present width is about that to which it has been contracted artificially above. This point is found below Warwick Bar, 1¾ miles below the lowest wing-dam already built, and 5¼ miles below the city. Below this, as far as Dutch Gap, the river has an average width of about 600 feet, and a depth of channel at low tide, except for a short distance in Kingsland's reach of *at least* 18 feet at high tide. Warwick Bar is now about 2,000 feet above its location in 1852, as shown on the Coast-Survey chart. It is now just above Gunn's wharf, the site of a military bridge during the civil war. Portions of sunken vessels and other obstructions still remain there, but they are not in the usual track of vessels. From this point downward there is now a good channel, with from 16 to 17 feet at high-tide. Over the present bar, which is 500 feet long, there are but little over 15 feet. There were two lines of cribs and vessels sunk on old Warwick Bar during the war, the lines not being continuous. Many of these were removed under your instructions. Those now remaining are causing irregular scour. The effect on the fair-way for vessels has been beneficial, as it is 3 or 4 feet deeper opposite the obstructions than was found by the Coast Survey in 1852.

In regulating the width of the river here it would seem advisable to remove all the remaining obstructions which are within the contemplated lines of contraction.

It was suggested, in the last annual report, that the depth to which the improvement should be carried below Warwick Bar should be 18 feet at low-water, instead of that now intended of 15 feet. The reason given was, that vessels loaded for the *high-tide* depth at Richmond should be able to pass all the lower shoals *at any stage* of the tide. It is not unlikely that the work of deepening below Warwick Bar, at least where the shoals are of sand or light earth, can be accomplished by properly-located training-

walls, and the increased expense on bars of harder material would not be considerable for the greater depth.

The following statement of shoals below Warwick Bar, with their length at certain depths, has been compiled from maps in this office, and is submitted for your consideration. It has been impossible, with the means in hand, to examine the character of these lower shoals during the past year, so as to make a reliable estimate of the cost of their removal, but it is important to have this information as soon as practicable.

Shoals in James River between Warwick Bar and Hampton Roads, with less than 22 feet, *low tide*.	Authority.	Miles from Richmond.	Least channel-depth mean low tide, feet.	Least channel-depth mean high tide, feet.	Length of shoal with less than 18 feet at high tide, feet.	Length of shoal with less than 18 feet at low tide, feet.	Length of shoal with less than 20 feet at low tide, feet.	Length of shoal with less than 22 feet at low tide, feet.
Near Falling Creek	Engineer survey, 1874	6¼	16½	20¼	0	2,000	4,800	6,500
Kingsland's Reach	......do	10½	13	16.3	780	1,700	4,000	5,800
Dutch Gap Canal	Engineer survey, 1876.	14½	14½	17.6	120	600	625	650
Aikin's	Coast survey, 1852 ...	15½	15	18.2	0	1,800	2,000	2,500
Above Deep Bottom, ½ mile.	......do	18	19	22.2	0	0	1,400	2,100
Jones's Neck, lower end	......do	21½	15	18.2	0	2,000	2,400	3,400
Curle's Neck, lower end	......do	26½	17½	20.7	0	200	600	1,300
Above Bermuda Hundred.	......do	30½	15	17.8	200	2,100	2,700	7,200
Harrison's Bar..........	Coast survey, 1875	37½	14	16.7	700	5,700	6,000	6,100
Opposite Chickahominy River.	Coast survey, 1874	60	17½	20.2	0	1,000	8,600	12,000
Above Swan Point......	......do	64	17	19¾	0	3,900	5,300	16,000
Hog Island Bar	Coast survey, 1873	71	15	17¾	300	5,280	9,240	12,440
Near Skiff Creek	......do	76½	19	21½	0	0	9,000	12,000
Point of Shoals	Coast survey, 1852	87½	19	21½	0	0	2,000	4,000
					¾ mile.	5 miles.	11.1 m's	17.4 m's.

The distances from Richmond were scaled from published maps, but may not be very accurate. They were measured via Dutch Gap canal. The Coast-Survey charts show a channel to the north of White Shoal light-house, with at least 25 feet at low-tide.

SURVEYS.

A resurvey of the river from the ship-lock to 5½ miles below has been made, and also of Kingsland's reach. The soundings on the latter are still incomplete.

It is proposed also to resurvey the river from about 1 mile above to 4 miles below the Dutch Gap canal, to ascertain what changes, if any, have occurred since that work was opened.

PRESENT CONDITION OF THE CHANNEL.

At mean high tide, which is assumed to be 3½ feet above the zero at Rockett's Reef, there is a minimum depth in the channel over the reef of 14.2 feet; thence to the sea there is a minimum depth of 14½ feet.

OBSERVATIONS ON THE TIDES.

One of the registering tide-gauges, which at the date of the last report was at the Chesapeake and Ohio Railroad wharf, was removed to Rockett's in October, 1876. The other, which was at Dutch Gap, was removed to Richmond Bar in March, 1877. The observations taken at Rockett's from October to May, inclusive, except those for December and January, (which were very imperfect.) Those taken at Dutch Gap for October and November, 1876, and those taken on Richmond bar in April, May, and part of March, are given below.

Owing to a misunderstanding of the value of the scale of reduction on the gauge used at Dutch Gap, the results for that station published in the last report are incorrect. A corrected station, now given, shows that the observations made in 1874 by Mr. Popp agree more closely with these more extended observations than was stated. The mean low tide, as given by him, is 0.161 lower than the mean of observations in 1875–'76, and 0.33 lower than the mean of October and November, 1876.

Station.	Period of observation.	No. of months.	Lune-tidal interval.		Duration.		Mean rise and fall.	Extreme high water above 0.	Extreme low-tide above 0.	Mean height of low-tide above 0.
			High-tide.	Low-tide.	Flood.	Ebb.				
			h. m.	*h. m.*	*h. m*	*h. m.*	*feet.*	*feet.*	*feet.*	*feet.*
Chesapeake & Ohio Railroad wharf.	September, 1875, to June, 1876.	9	17.10	24.28	5.07	7.18	3.49	*12.10	—2.40	—0.14
Dutch Gap	September, 1875, to June, 1876.	9	16.25	23.17	5.29	6.56	3.29	5.35	—2.10	+0.23
Dutch Gap	October and November, 1876.	2	......	......	......	......	3.72	5.00	—1.50	+0.40
Rockett's Reef	October and November, 1876, and March to May, 1877.	4½	17.13	24.29	5.02	7.23	3.31	†6.90	‡—2.10	+0.16
Richmond Bar	March to May, 1877.	2½	16.47	24.14	4.59	7.26	3.28	†6.95	—0.80	+0.434

*Freshet. †April 10, 1877. ‡October 17, 1876.

Comparing the tidal observations at Rockett's and Richmond Bar in April and May, 1877, the latter being 2¼ miles below the former, we find:

	Rockett's.	Richmond Bar.
	Feet.	*Feet.*
Mean rise and fall of tide	3.079	3.310
Mean height of low tide above zero	0.684	0.436
Highest high tide	6.90	6.95
Lowest low tide	0.80	0.80

The zero at Richmond Bar is supposed to be 0.05 foot below that at Rockett's, and, assuming this to be correct, the mean fall at low tide for these months was 0.298 foot. The tidal range at Drury's Landing, 7 miles below Richmond, was by the survey of 1874 0.25 foot greater than at Rockett's. The contraction by the wing-dams at the bar may have raised the level of both high and low water. The fall from Rockett's to Richmond Bar at low tide in 1874 was found to be 0.58 foot at a point about one-fourth mile farther down than the present gauge. The high tide of April 10, 1877, is the highest observed since I was placed in charge of the work in July, 1874, and I believe for a much longer period. It was caused by an easterly gale on the coast.

ESTIMATE FOR JAMES RIVER IMPROVEMENT, 1877—DEPTH 15 FEET AT LOW TIDE, AND WIDTH OF CHANNEL 180 FEET.

Richmond dock to Rockett's Reef:		
16,000 cubic yards dredging, at 50 cents	$8,000 00	
300 cubic yards rock, at $10	3,000 00	
		$11,000 00
Across Rockett's Reef:		
5,486 cubic yards rock, at $10		54,860 00
Rockett's Reef to lower end of Drury's Island:		
60,000 cubic yards dredging, at 50 cents	$30,000 00	
1,680 linear feet timber groins, at $1.75	2,940 00	
		32,940 00
Channel at Goode's Rock:		
1,600 cubic yards rock, at $9	$14,400 00	
2,000 cubic yards dredging, at $1.50	3,000 00	
		17,400 00
Across Richmond Bar and Randolph Flats:		
40,000 cubic yards dredging, at 25 cents	$10,000 00	
3,000 linear feet timber groins, at $1.75	5,250 00	
		15,250 00
Across Warwick Bar:		
20,000 cubic yards dredging, at 25 cents	$5,000 00	
8,000 linear feet timber dikes, at $3.50	28,000 00	
		33,000 00
Kingsland's Reach:		
13,000 cubic yards dredging, at 25 cents	$3,250 00	
2,200 linear feet timber dikes, at $3.50	7,700 00	
		10,950 00

Dutch Gap Cut-off:		
22,000 cubic yards excavation, at 25 cents	$5,500 00	
10,000 cubic yards dredging, at 50 cents	5,000 00	
		$10,500 00
Aikin's, (from coast survey, 1852:)		
48,000 cubic yards dredging, at 25 cents	$12,000 00	
3,000 linear feet timber dike, at $4	12,000 00	
		24,000 00
Across Harrison's Bar, (from coast survey, 1875:)		
Channel 200 feet wide by 16 feet at low tide.		
12,800 cubic yards dredging, at 40 cents		5,120 00
Contingencies, 20 per cent		43,001 00
Total		258,024 00

The change in the width and depth at Harrison's Bar to 200 by 16 feet at low tide is suggested on account of its importance and because the range of tide is from 0.5 to 0.8 foot less than at points above. The estimate is submitted with the supposition that the prices for labor and materials will remain as at present, and that full appropriations are made so as to avoid the increase in expense attending intermittent and incomplete operations.

COMMERCIAL STATISTICS.

The following letter from the collector of this port has been received:

CUSTOM-HOUSE, RICHMOND, VA., *June* 6, 1877.

DEAR SIR: Inclosed I furnish a tabular statement of the number of vessels, tonnage, and export transactions at this port for one year from June 1, 1876; also a statement of revenue derived from imports.

I feel a deep interest in the success of the improvement, and it will afford me much pleasure to give it such aid as is within my power.

Very truly, yours,

CHARLES S. MILLS,
Collector.

Mr. H. D. WHITCOMB,
Assistant Engineer.

Vessels, tonnage, and exports from port of Richmond for year ending May 31, 1877.

Vessels.		Flour.	Petroleum.	Tobacco.	Coal.	Bark.	Lard.	Staves.	Hoop-poles.	Rosin.	Cotton goods.	Steam-engines	Slate.	Cotton.	Timber.
No.	Tons.	Bbls.	Bbls.	Hhds.	Tons.	Bags.	Kegs and pails.	Pieces.	Bundles.	Bbls.	Bales and cases.	No	Tons.	Bales.	Pieces.
136	47,575	162,867	117,341	8,208	1,442	5,974	1,450	71,032	26,630	740	54	1	365	3,910	5,121

Of the number of vessels, two of them rated over 800 tons each, and twenty-one over 500 tons each.

The amount of revenue derived from imports for the year ending May 31, 1877, was $21,880.87.

Through the courtesy of P. H. Russell, esq., collector of internal revenue for Richmond district, I learn that the collections of this district from July 1 to May 31, inclusive, a period of eleven months, amounted to $3,017,796.88.

The following quotation from the annual report of R. E. Blankenship, esq., chairman of the James River Improvement Committee of Richmond, dated February 1 1877, will show as nearly as practicable the amount of tonnage, &c., of this port for the years ending December 31, 1875 and 1876.

It is unnecessary to allude to the great benefits of this improvement to the city, as that is conceded and applauded by all classes of people; but it is quite proper that we should hold up for the general information the increase in number and size of vessels, and we regret that there is no means at our command by which we can show the increase in the tonnage of the port for the year. Fortunately the Chesapeake and Ohio

Railroad Company give careful attention to this important matter, and through the courtesy of the officers we are enabled to state exact figures, and they may, to a fair extent, be used as a basis for estimating the increase of tonnage for the port.

In 1875, 236 schooners, 4 barks, 1 brig, entered at Chesapeake and Ohio wharves, carrying 102,217 tons of freight.

In 1876, 443 schooners, 29 barks, 1 brig, entered, carrying 154,617 tons of freight. A clear increase in one year of 64 per cent. in number of vessels and 54 per cent. in tonnage. The business at these wharves is rapidly increasing, and the receiver assures us that he expects during 1877 to double the tonnage of last year.

The officers of the Chesapeake and Ohio Railroad Company are much pleased with their prospects for tonnage, and unhesitatingly attribute their success to the improvement of the James River.

The Richmond dock has no account of the tonnage passing its gates. * * * We annex a statement of vessels entering the lock:

In 1875, 1,404 of all classes.

In 1876, 1,715 of all classes.

Showing an increase of 22 per cent. in the year. This is surprising in face of the fact that vessels of greater draught were coming up to Rockett's wharves all during 1876 than could cross the miter-sill of the ship-lock.

The shipments of flour and tobacco in large vessels from Rockett's was a regular business during 1876, and the good effects have already been felt in that almost deserted part of our port.

At the Richmond and Danville Railroad wharves many cargoes of heavy merchandise—coal and railroad-iron—have been discharged between vessels and cars and the expense of transfer through the streets avoided.

The New York steamers are bringing largely increased cargoes, and making their arrivals and departures without waiting for the rise of the tide. Lightering goods, except for vessels drawing over 14 feet, is about abandoned on the river. * * *

The Richmond Despatch, January 1, 1877, gives the harbor-master's report for the previous year, stating the number of vessels that entered at Richmond during the year, excluding river and oyster craft, as follows: Barks 49, brigs 53, schooners 680; number of sail-vessels 782, side-wheel steamers 304, propellers 268; whole number of steamers 572; whole number of arrivals 1,354. Amount of tonnage for sail-vessels, 152,000 tons; average for this over last year, 20 per cent. Amount of tonnage of steamers, 500,000, an increase over 1875 of 10 per cent.

The city of Richmond has in furnishing machinery and by a limited appropriation aided in carrying on the work in the past year.

Very respectfully your obedient servant,

H. D. WHITCOMB,
Assistant Engineer.

Col. WM. P. CRAIGHILL,
Major Corps Engineers, U. S. A.

F 5.

IMPROVEMENT OF THE APPOMATTOX RIVER, VIRGINIA.

On the 1st of July, 1876, Mr. G. H. Ferris was still engaged, under his contract of December 31, 1875, for widening the Puddledock Channel. He completed his work on the last day of August, 1876, the channel being left with a width of about 100 feet and a depth permitting vessels drawing 10½ feet to pass with ease. This new cut is now used almost entirely.

A new appropriation of $30,000 was made by the act of August 14, 1876, of which $15,000 became available about the middle of September. Proposals were at once invited for raising the banks of the Puddledock Channel at some low places where the water in freshets threatened to break through from the old channel. The contract was awarded October 18, 1876, to Mr. W. H. Beard, the lowest bidder. Work was begun in November, 1876, and finished in June, 1877. The material for the banks is gravel taken from the adjacent channel. About 35,000 cubic

yards have been used for that purpose. To secure the bank, willows have been planted. A small quantity of rip-rap stone has been used.

It is not considered that the Puddledock Channel needs further work at present. The river between the upper end of that channel and the city of Petersburg now needs attention, and it is expected to expend there before the close of 1877 the remainder of the appropriation of August 14, 1876.

Mr. H. D. Bird has continued, as heretofore, the resident engineer at Petersburg.

Money statement.

July 1, 1876, amount available	$7,613 17
Amount appropriated by act approved August 14, 1876	30,000 00
	37,613 17
July 1, 1877, amount expended during fiscal year	22,042 08
July 1, 1877, amount available	15,571 09
Amount (estimated) required for completion of existing project	83,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	50,000 00

Proposals for dredging Appomattox River, opened at 1.05 o'clock p. m., October 18, 1876.

No.	Name.	Residence.	Price per cubic yard.	Time. Commence—	Time. Complete—	Remarks.
			Cents.			
1	G. H. Ferris	Brooklyn, N. Y	37	Nov. 1, 1876	July 1, 1877	
2	W. H. Beard	Brooklyn, N. Y	30	Nov. 15, 1876	June 30, 1877	Contract awarded.
3	M. F. Brainard	Albany, N. Y	31¼	Jan. 1, 1877	June 30, 1877	

REPORT OF MR. H. D. BIRD, ASSISTANT ENGINEER.

PETERSBURG, VIRGINIA.

COLONEL: I have the honor to report to you the progress made in this improvement during the past twelve months.

In June, July, and August, 1876, Mr. G. H. Ferris, the contractor, was engaged in finishing his contract for widening Puddledock Channel to 100 feet (which work he had commenced in January of that year,) and dredged out 38,177.50 cubic yards. This, added to the number of yards taken out previously, made 112,537 yards, the whole number dredged in widening this channel. It is now sufficiently wide to accommodate vessels passing each other.

In the month of October, 1876, a contract was made with W. H. Beard for making an embankment to protect two low places on the north shore of this channel, which were liable to be damaged by freshets. The work was commenced on the 15th of November, and up to this date he had filled in 29,182.5 yards, making, with the first three months' work, 67,360 yards done in the fiscal year.

Vessels drawing 11 feet water can now reach the city.

There has been dredging enough done on the river to accommodate its present trade. But it is very necessary to continue the works now under execution of protecting the channels which have been dredged out from injury by freshets. The embankment now completing in Puddledock will secure that portion of the improvement; but there are other places that equally need securing. Indeed, the amount of damage done by a single freshet in the winter of 1874-'75 to the Petersburg Channel, admonishes us that the work of protection cannot be deferred without risk of further injury to the improvement.

As directed in your circular of March 22 last, I have added to this report the statistical information in regard to the business of Petersburg, called for by the Chief of Engineers, to enable him to report upon the value of this improvement to the Government. I do this the more readily, as our river is a short one and apparently a mere local work, as would seem from the present amount of commerce on it. But this is no indication of the real amount of business done in the city. The statistics given below

sufficiently prove that even in these times of general depression of business, Petersburg is a place of considerable importance, and can be made more so by the completion of our river improvement. The internal revenue-tax paid the Government affords ample proof of this. You will find among the statistics given that the collector of that revenue says the amount for this fiscal year will be $2,500,000. And you will see further he states that in the twelve years since the war there was collected at this office fully $24,000,000 of internal revenue.

When it is recollected that this revenue was paid in a city of 20,000 inhabitants, which had just emerged from a ruinous war, and had been materially damaged by a ten months' siege, whose commerce and trade had to be built up again from the foundations, and whose prosperity in its first dawn was clouded over by the financial storm of 1873, which fell upon this city with greater violence than elsewhere, I think it indicates a vitality in the spirit of the people and a strength in its natural position for commerce which entitle it to the generous consideration of Congress.

In order fully to comply with the requisition of the Chief of Engineers, I beg leave to give a brief account of our river improvement, to show not only its value to our people, but the interest the public at large have in its completion.

Over half a century ago the commerce of the city had increased so much that the merchants raised a company to improve the navigation of the river.

The work was commenced, and in a few years the depth of water was nearly doubled. This gave such an impulse to the trade of the city that the improvement would undoubtedly have been carried on to completion if it had not been interrupted by the question of railroads, which then began to attract the public attention. The citizens of Petersburg were the first to take a practical interest in this question. Without pausing to witness its effect upon larger communities, they boldly projected and as boldly commenced the construction of 60 miles of railroad to North Carolina, and it was one of the first completed in the United States for the purposes of general transportation. They also built a railroad to City Point, with the expectation that it would answer better than the improvement of the river, it being one of the exaggerated notions of that day that railroads would supersede canals.

But it was not long before the merchants found that the cost of maintaining even a short railroad, added to the delay of transshipment, was too great a burden on their trade; and Congress having at that time commenced improving the rivers and harbors of the country, a small sum was appropriated to improve the James and Appomattox Rivers. This turned attention to the river again.

A Government engineer was sent on to survey and lay down a plan of improvement for it, and the work was soon commenced. But unfortunately for the interests of Petersburg, the southern members of Congress of that day were opposed to expending money on works of this kind, and no more appropriations were made for our river. The Government engineers were withdrawn, but the city council took up the work where they left it, and continued it; and when the war broke out, they had succeeded in deepening the navigation to such an extent that vessels drawing 9 feet could reach the city.

In the mean time the line of railroads commencing at Petersburg and running west to Lynchburg, and southwest to Memphis and New Orleans, had been completed, and the companies owning them had united in one line for the receipt and transport of merchandise to City Point, the port of Petersburg, and thence by steamship lines to New York and other northern cities. This through line worked so well that at the time hostilities commenced the tonnage carried on it had grown to great importance and was increasing every day. While this promising business was going on the city council was busily prosecuting the work on the river, and if it had not been for the interruption caused by the war, the improvement would have been completed, and Petersburg years ago would have become the point of shipment of this large tonnage, and her citizens would now be reaping the reward of their enterprise and expenditure in opening the route for it. Instead of that they behold this traffic, now grown to gigantic proportions, carried through their streets and along their wharves to go 80 miles further by rail to Norfolk for shipment.

How this was accomplished is explained in a few words. When the war ended the citizens of Petersburg found themselves impoverished and well-nigh ruined by it; and they had literally to commence and build up a new trade again. But this was not the worst of their calamities. They found their railroad with its depots and bridges burnt, its rails, engines, and cars worn out, and the company owning it worse off than themselves, without funds, without credit, and without friends to aid it.

While the citizens were busily engaged in trying to recover from their losses, the railroad fell into the hands of capitalists who raised the means to rebuild it. This was soon done, but the road was not rebuilt in the interests of Petersburgh. The persons who obtained control of it found it to their interest to add to it the 80 miles of railroad to Norfolk; and thus was Petersburg deprived of the business which legitimately belonged to her, and for which she had toiled and spent her treasure before the war.

There was no other reason for this procedure. If Norfolk had been the port of James

River, if any of this tonnage had been shipped that way before, if even it was a better port than the port of Petersburg (City Point) or the nearest and cheapest point of shipment, there might have been some justification for the act. But there was none. Up to the war the through tonnage had been shipped from City Point as cheaply as freight could be shipped from Norfolk, and by the same line of steamships which now takes it from Norfolk. And to show beyond all doubt that it is a mere arbitrary arrangement of the parties controlling the railroad, I will state further, that the steamship company which *then* took the freight from City Point, *now* run their steamships *empty* from City Point to Norfolk, and they take the freight there, after it is carried over the 80 miles of railroad between Petersburg and Norfolk. This makes this case as much a wrong to the public who use this route as it is to the people of Petersburg, and I respectfully suggest an inquiry into it by the power competent to remedy it.

This railroad has to be kept up, and it can only be done by a charge on the through tonnage, which charge comes out of the pockets of the merchants of the North and South who own the tonnage. It is in effect a tax levied upon them to support the railroad; and perhaps it may induce them or their representatives in Congress to examine into it, to see how much money can be saved to the country by restoring the tonnage to its ancient route.

The railroad is in the hands of receivers, and no published reports are made at present. But I have in my hand a report of the company for 1872, which shows that the through tonnage of that year, carried both ways, between Petersburg and Norfolk on the railroad, was 90,617 tons, and that it paid for transportation over the road, $213,131.18. It is doubtless much greater now, as the tonnage is an increasing one. But surely a tax of over $200,000 a year on the country is an evil of such magnitude that it ought to be abated.

This, it is believed, can be effectually done by the completion of the Appomattox River improvement, and by some legislation of Congress to regulate the intercommerce of the States, to protect them from abuses of this kind.

Respectfully, your obedient servant,

H. D. BIRD.

Col. WM. P. CRAIGHILL,
Major Corps of Engineers, U. S. A.

STATISTICS OF THE CITY OF PETERSBURG, VA., FOR THE YEAR 1877.

Population, (by last census)	18,950
Internal revenue:	
Paid the General Government for the last fiscal year	$2,250,000 00
Paid the General Government during the twelve years since the war	24,000,000 00
Valuation of taxable property:	
Real	$6,000,000 00
Personal	3,000,000 00
	9,000,000 00
Taxes paid:	
State	$55,624 47
City	195,000 00
	250,624 47
Tonnage:	
River, 351 vessels	30,000
Railroads:	
Atlantic, Mississippi and Ohio. (No reports.)	
Petersburg and Weldon Railroad	60,000
Petersburg and Richmond	85,773
Agricultural products sold in Petersburg, value:	
31,000 bales cotton	$1,750,000 00
11,931 hogsheads tobacco	3,500,000 00
Loose tobacco	4,750,000 00
250,000 bushels wheat	450,000 00

300,000 bushels corn	$180,000 00
300,000 bushels peanuts	240,000 00
60,000 tons sumac	360,000 00
Hay, oats, and shucks	60,000 00
Eggs, butter, &c	50,000 00
	11,340,000 00

Merchandise sold in Petersburg, value:

Groceries	$3,750,000 00
Dry-goods	1,250,000 00
Clothing	400,000 00
Shoes	325,000 00
Hats and caps	175,000 00
Hardware, stoves, and tinware	400,000 00
Crockery and stoneware	100,000 00
Hides and leather	60,000 00
Books, stationery, and musical instruments	90,000 00
Fertilizers	125,000 00
Lumber	220,000 00
Coal and wood	180,000 00
Miscellaneous	110,000 00
	7,185,000 00

Manufactories, value of products:

7 cotton; 36,000 spools	$720,000 00
22 tobacco-factories	2,870,000 00
5 flour-mills	625,000 00
5 corn-mills	100,000 00
2 iron-works	175,000 00
4 printing-offices	85,000 00
Coach and wagon factories, &c	250,000 00
	4,825,000 00

Banking and insurance companies:

6 companies; capital	$1,470,000 00
Private bankers	500,000 00
Deposits	950,000 00
	2,920,000 00

City property, value:

River improvement	$200,000 00
Wharves	20,000 00
Water-works	125,000 00
Public school-houses	55,000 00
Steam fire-engines	20,000 00
Railroad stocks	550,000 00
	970,000 00

LETTER FROM COLLECTOR OF INTERNAL REVENUE.

UNITED STATES INTERNAL-REVENUE COLLECTOR'S OFFICE,
SECOND DISTRICT VIRGINIA,
Petersburg, June 6, 1877.

SIR: As desired I give below wished-for information.

The amount of internal revenue received at this office during the last fiscal year was $962,591.09. In addition to this, 4,680,000 pounds of manufactured tobacco was exported from this city to various parts of the world, representing a revenue-tax of $1,123,200 if paid.

From my knowledge of the business of this office, I can, with perfect safety, state that the amount of internal-revenue taxes, including the tax represented by tobacco bonded during the last twelve years, at fully $24,000,000, an average of $2,000,000 per

annum. The amount for the present year will be fully $2,250,000, as the revenue de rived from the business of this city is steadily increasing.

Very respectfully,

C. A. RICHARD,
Collector.

H. D. BIRD,
U. S. Assistant Engineer

F 6.

IMPROVEMENT OF THE GREAT KANAWHA RIVER, WEST VIRGINIA.

On the 30th of June, 1877, five contracts were in force, as follows: with D. M. and C. P. Dull, August 20, 1875, for building lock No. 5, near Brownstown; with C. McCafferty, October 15, 1875, for building lock No. 4, near Cabin Creek Shoal; with J. H. Shultz, March 28, 1876, for building the dam, abutment, pier, and floor of a navigation-pass adjoining lock No. 5; with Freeman, Richardson & Fraser, May 1, 1877, for a dam, abutment, pier, and floor of a navigation-pass adjoining lock No. 4; with W. M. Archer, May 23, 1877, for the iron work of the pass and wier of dam 5.

The details of the operations of the fiscal year are set forth in the accompanying report of Lieut. Thos. Turtle, Corps of Engineers, who has been the resident engineer in immediate supervision of the work; The working season of 1876 was reduced to but a few days, comparatively, owing to the unusual frequency of freshets, which prevented such progress with the operations as was expected, and would have been made if the condition of the river had permitted. This cause of delay is, of course, beyond control.

Every suitable day has been taken advantage of for laying masonry in the foundations. Much material has been prepared and is in readiness for introduction into the structures. It is certainly expected that a good showing will be made by the end of 1877, unless there should be a recurrence of the freshets which were so frequent in 1876.

An appropriation of $270,000 was made by act of August 14, 1876, of which $15,000 became available in September, 1876, $170,000 in January, 1877, and the remaining $85,000 in March, 1877. Additional contracts were entered into as soon thereafter as they could be made. Negotiations were also commenced by the United States district attorney for the acquisition of sites near Paint Creek, where are to be located lock and dam No. 3. These are still in progress.

While the works for the permanent improvement by locks and dams are incomplete, where begun, and limited in extent as to localities occupied, owing to inadequate appropriations, there are points not affected by such permanent works which require a small expenditure for their temporary amelioration. Operations of this character have been considered necessary at but one such point during the fiscal year, viz, at Red House Shoal. This work was resumed in September and completed in November, 1876. Reference is requested to the accompanying report of Mr. A. M. Scott on that subject. Mr. Scott has also been constantly and very efficiently engaged on the works of permanent improvement and in special surveys and examinations, which have been and will continue to be from time to time necessary.

Mr. W. R. Hutton has continued during the year, by constant conference, aid, and advice, to give me the benefit of his extensive professional knowledge and experience.

A series of connected observations have been made at several points on the New River, below the mouth of the Greenbrier, for the purpose of determining the effect of freshets in the New River upon the regimen of the Kanawha. Some observations have also been made on the Elk River with a similar object.

The appropriations have been: March 3, 1873, $25,000; June 23, 1874, $25,000. Expended in the temporary improvement, March 3, 1875, $300,000; August 14, 1876, $270,000. The total of the estimate for the permanent improvement was $4,153,000, but it is believed the work can be done for considerably less, as the estimate was full and the contracts thus far have under-run the estimates.

To show the commercial importance of the improvement of the Great Kanawha River, extracts have been freely made from a volume prepared by Professors M. F. Maury and W. M. Fontaine, entitled "Resources of West Virginia."

Money statement.

July 1, 1876, amount available	$271,460 49	
Amount appropriated by act approved August 14, 1876	270,000 00	
		$541,460 49
July 1, 1877, amount expended during fiscal year	93,875 85	
July 1, 1877, outstanding liabilities	25,266 47	
		119,142 32
July 1, 1877, amount available		422,318 17
Amount (estimated) required for completion of existing project		$3,582,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		500,000 00

Proposals for two sets of culvert pipes and gates for locks on the Great Kanawha River, West Virginia, opened at 12.05 p. m., August 16, 1876.

No.	Name.	Residence.	Price for each set delivered complete.	Remarks.
1	O. A. & W. T. Thayer.	Charleston, W. Va	....	$6,360 for both sets at lock site; to deliver within 60 days from date of contract.
2	Poole & Hunt........	Baltimore, Md	Will deliver them on cars at Coalburgh or Brownstown Station, Chesapeake and Ohio Railroad, for $5.50 extra.	To be delivered in cars at Baltimore; $5,200 for both sets in 4 weeks; $4,800 for both sets in 7 weeks.
3	H. A. Ramsay & Co..	Baltimore, Md ...	$1,947 80	To be delivered within 12 weeks of date of contract, at lock site.
	All rejected.			

Abstract of proposals for building a dam on the Kanawha River, near Cabin Creek, opened at 12.05 p. m. April 5, 1877.

Number.	Name.	Residence.	Clearing and grubbing.	Earth excavation, per cubic yard.	Rock excavation, per cubic yard.	Puddling, per cubic yard.	Concrete, per cubic yard.	Coping, per cubic yard.	Cut-stone masonry, per cubic yard.	Dressed rubble masonry, per cubic yard.	Rock-faced masonry, per cubic yard.	Rough rubble masonry, per cubic yard.	Slope wall, including lining, per cubic yard.	Riprap, per cubic yard.	Paving, per cubic yard.	Timber and plank per 1,000 feet, board measure.
1	F. C. Crawley	Baltimore	$400 00	$0 60	$2 50	$1 00	$5 50	$25 00	$13 00	$11 00	$9 00	$6 50	$4 50	$4 00	$12 00	$20 00
2	N. H. Squair	Cincinnati, Ohio	500 00	1 00	2 50	80	10 00	25 00	25 00	20 00	18 00	16 00	12 00	10 00	14 00	40 00
3	Smith & Smith	Baltimore, Md	....	1 00	1 50	3 00	8 00	20 00	19 00	16 00	16 00	7 00	7 00	7 00	6 00	60 00
4	Weaver, Heikel & Gayton	Huntingdon, Pa	....	1 30	4 50	1 50	6 50	33 00	32 00	28 00	26 50	25 50	10 00	6 00	34 00	56 00
5	Kelly & Haviland	Chattanooga, Tenn	....	1 00	2 00	1 00	6 00	15 00	12 00	10 00	10 00	8 00	4 50	2 50	4 00	43 00
6	Palmer, Miller & Miller	Coalburg, W. Va	800 00	2 00	1 25	50	7 50	25 00	23 00	14 50	13 50	9 00	5 00	2 50	12 00	42 00
7	Freeman, Richardson & Fraser.*	Watertown, N. Y	†100 00	50	3 00	50	3 50	17 00	15 00	10 00	10 00	6 00	3 50	1 50	3 50	26 00
8	Huston & Co	Chattanooga, Tenn	....	80	1 50	25	6 50	12 00	10 00	8 50	8 50	5 00	2 00	1 00	4 00	30 00
9	Walter Doty	Fort Edward, N. Y	....	1 00	5 00	1 00	8 00	40 00	30 00	25 00	25 00	15 00	6 00	2 00	20 00	60 00
10	C. J. De Graw	Fulton, N. Y	†100 00	30	1 00	20	3 00	12 00	8 00	4 00	6 00	3 00	1 50	1 00	2 00	40 00
11	T. McCann	Brooklyn, N. Y	†2, 250 00	1 50	10 00	3 00	6 00	30 00	30 00	15 00	15 00	10 00	8 00	5 00	10 00	50 00
12	J. G. Noakes	Scranton, Pa	†600 00	75	2 50	2 00	6 90	40 00	30 00	26 00	25 00	14 00	7 00	5 50	16 00	40 00
13	Rogers & Scully	Saint Louis, Mo	....	1 17	4 50	1 80	8 60	27 45	27 45	19 50	17 00	9 20	9 45	4 50	19 45	36 00
14	Friday & Stracham	Pittsburg, Pa	....	2 00	5 00	1 25	7 25	19 00	16 80	13 50	13 50	8 50	7 00	2 75	14 00	30 00
15	Dull & Dull	McVeytown, Pa	....	2 00	3 00	2 75	11 00	22 00	28 00	15 00	14 50	12 00	8 00	3 00	15 00	65 00
16	J. A. Green	Ramapo, N. Y	....	55	2 25	1 25	6 00	30 00	25 00	15 00	12 00	10 50	5 00	1 50	7 00	60 00
17	Fowley, Ernshaw & Co	Cincinnati, Ohio	1, 600 00	1 92	2 70	1 08	11 73	16 63	15 43	13 93	13 03	8 83	9 43	4 80	19 93	36 00
18	C. J. McDonald	Baden, Pa	800 00	40	2 00	50	8 00	20 00	18 00	15 00	11 00	10 00	5 00	2 50	9 00	40 00
19	Saterlee & Penny	New York	350 00	60	2 50	1 25	7 00	30 00	30 00	14 00	11 00	11 00	5 00	1 00	8 00	60 00
20	Hart & O'Connor	Ironton, Ohio	†50 00	1 50	4 00	1 50	7 00	27 00	27 00	13 00	12 50	10 00	5 00	2 00	13 00	55 00
21	McMahon, Green & Connor	Staunton, Va	....	1 12	4 50	42	8 70	30 80	25 20	14 80	14 80	9 80	7 00	3 50	14 00	42 00

* Contract awarded. † Per acre.

Proposals for the iron-work of a movable dam on the Great Kanawha River. Bids opened at 12.5 p. m. May 16, 1877.

No.	Name.	Residence.	Price.
1	H. A. Ramsay	Baltimore	$21,000
2	A. Hartupee	Pittsburg, Pa	14,850
3	Wilcox, Shinkle & Miller	Pittsburg, Pa	18,970
4	Lane & Bodley Company	Cincinnati	26,578
5	J. R. Anderson	Richmond	17,900
6	A. G. Moore	Cincinnati	26,820
7	Cooper Manufacturing Company	Mount Vernon, Ohio	23,449
8	W. Bollman	Baltimore	24,494
9	J. W. Jones	Philadelphia	19,500
10	William M. Archer*	Richmond	13,610

*Contract awarded.

REPORT OF LIEUTENANT THOMAS TURTLE, CORPS OF ENGINEERS.

U. S. IMPROVEMENT GREAT KANAWHA RIVER,
Charleston, Kanawha County, W. Va., June 18, 1877.

MAJOR: According to instructions, I submit the annual report of progress in the improvement of the Great Kanawha River for the year ending June, 1877.

Mr. A. M. Scott was in immediate charge of the work from June 30, 1876, the beginning of the fiscal year, till my arrival, under order from headquarters Corps of Engineers, on August 29, 1876.

LOCK NO. 4.

At the commencement of the fiscal year the contractors were engaged in quarrying stone, stripping quarries, breaking concrete stone, and dredging on the lock-site preparatory to placing the coffer-dam. It was found that among the material to be removed from the lock-site was a considerable quantity of logs and stumps of large size. No indications of these were seen till the dredge discovered them.

The framing of the coffer-dam began on June 26, 1876, and the placing of it upon the site commenced July 26. Plan and sections of this coffer-dam are inclosed, (sheet No. 1.)

Besides the puddling in the dam, it was embanked upon the outside. August 14 the work of placing the coffer-dam was suspended by a rise in the river, but was resumed on the 15th. The planking of three sections was displaced by the freshet. On August 21 the coffer-dam burst open at the up-stream outer corner by the pressure of the puddling thrown into it. An angle-shaped crib-work was then put in, embracing, protecting, and supporting the upper and outer sides of this corner. This crib-work is eight feet wide, and extends to a little above the top timber or stringer of the coffer-dam.

This crib was commenced on August 23, and completed on August 29, on which day the dredge finished its work.

Work on the coffer-dam was again suspended on September 11, by a rise in the river. The placing of the coffer had at this time reached the lower end, and, returning, the lower corner and about half-way to the bank. When the water subsided, it was found that this returned portion had been thrown down stream, and its movement had swung the lower end on river side, outward from the corner to the third joint of stringer, up stream. To remove the débris and filling the dredge was again employed, and commenced work on the 1st of October. Nearly three weeks were lost by this rise. The placing of the coffer was completed on October 11, and by working night and day the filling progressed so that pumping began on the 14th. The pumping was done by a horizontal centrifugal pump, working at the bottom of the excavation, and run by a 14-horse-power engine, which, with its boiler, was placed on a flat moored alongside the coffer-dam. The water was well out on October 20. The capacity of the pump permits the coffer to be emptied in much less time than here shown, but some mishaps and delays, together with the desire to lower the water slowly in the first pumping, prevented quicker work. Excavation by hand in the lock-pit commenced October 19. The water being out, it was found that the dredge had not removed all the material to rock, as was supposed, but that a layer of bowlders and cemented gravel, unevenly distributed, overlaid the rock. The coffer-dam, therefore, rested upon this layer, and not upon the bed-rock, as was intended. On October 23 the coffer gave way at the lower end, from neglect to properly brace it, and moved inward 2½ feet on top, suspending the excavation. It was braced on the inside, and banked on the outside with clay. The leaks were all checked by next day, and excavation was resumed. As soon as the water was well out a ramp of trestles and planking was constructed at

the lower end of the lock-pit, so that the excavated material could be taken out in carts.

When the bed-rock was reached it was found to be exceedingly uneven. The rock-borings made in the survey of the site indicated a pretty level bottom, but it was worn into numerous gullies and pot-holes, showing that at one time it formed the immediate bottom of the river. The rock consists of a blue sandstone, remarkably free from seams; in fact, no leakage whatever appeared through it. In consequence, the concrete, to be overlaid with timber and plank for the bottom of the lock, was abandoned in the portion between the head and tail walls.

The first stone was laid on November 5, and the placing of concrete commenced on the 13th. The laying of masonry and the excavation of the lock-pit was carried on until November 21, when a rise in the river broke in the side of the coffer-dam and suspended work in the pit. This break occurred because the contractors had not taken precaution to properly brace the inside of the dam, as they had been requested to do. The sluice had been opened 1 hour and 35 minutes before the break occurred—too little time to fill the coffer.

When the dam gave way the river was 5.3 feet above low-water, and rising at the rate of one-tenth of a foot in 13 minutes. The break was repaired. Repairs were completed on December 16, the coffer-dam was braced by December 20, and three other sluices were put in. All work other than stripping quarries of stone was now suspended, as cold weather had set in.

From the close of the season of 1876 to February 10 operations were confined to stripping quarries and the quarrying and cutting of stone, as weather permitted. The river was closed by ice on January 2. The ice was broken up by a rise on January 12, and passed out without damage. On February 10 pumping was resumed, and the laying of masonry began again on the 15th. From this time till March 9 work went on rapidly, but a rise on that day suspended construction. The coffer was again pumped out, so that the laying of masonry, placing of timber, and excavation commenced on the 26th of March. A rise filled the coffer-dam in the afternoon.

From this time till May 23 six unsuccessful attempts were made to pump out. Finally, pumping was resumed on the 23d of May, and the laying of masonry was started on the 28th, and no interruption has ensued to the close of the report, (June 16, 1877.)

The following is a summary of the progress upon the construction of this lock: The average height of foundation (from rock to level of miter-sill) is about 5 feet 8 inches. The work is complete to the miter-sill, except as follows: about one-third of the paving and 17 running feet of the cross-sills below the upper miter-sill; 10 running feet of wall under cross-sills above lower miter-sills, and these cross-sills concrete above and below the lower miter-sills; paving round lower miter-sills; 27 running feet of the cross-sills at lower end of lock; the timber and plank flooring in the tail of the lock; and 14 running feet of upper wing-wall.

The superstructure is built as follows:

Upper wing, 26 feet in length at the bottom, stepping back to 16 feet in length at the top to reference (6′.5). [The top of miter-sill being at reference (0′.0).] This wing is to be 40 feet long.

Lower wing, (60 feet long,) to reference (3′.66) for full length, and to reference (7′.0) for 20 feet in length.

Land wall, to reference (4′.0) for 200 feet in length, to reference (6′.5) from head to outlet of flume, except one quoin-stone.

River wall, chamber side, to reference (4′.0) for 200 feet, and to reference (6′.5) to outlet of flume.

River wall, river side, to reference (2′.83) for 70 feet from head, to reference (4′.66) for 43 feet, and to reference (6′.5) for 12 feet.

DAM NO. 4.

The bids for this dam were opened on April 5, 1877, and on May 1 the contract was awarded to the firm of Freeman, Richardson & Fraser, of Watertown, Jefferson County, New York.

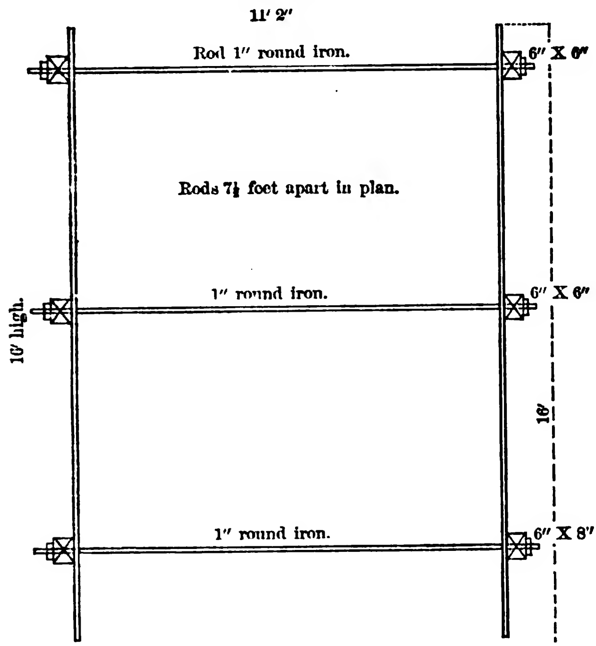
They arrived in Charleston on May 11, and immediately proceeded to make preparations for the execution of the work. At the close of this report (June 16, 1877) they have buildings constructed for the accommodation of employés, for office and blacksmith's shop. They have leased the land between the site and the railroad-track; made arrangements about quarries; commenced the stripping of the same; and have made arrangements with the railroad company to have a track and transportation from the quarries to the site. The grading of this track is complete. Timber for the first coffer-dam is in preparation.

This coffer-dam will include the space for the pier and about 120 running feet of pass. Excavation at the abutment site is begun. It is intended at this locality to dispense with a framed coffer-dam, as was done at the abutment of No. 5.

LOCK NO. 5.

At the time the annual report was made up for last year, (June 22, 1876,) work was suspended in the lock-pit on account of a rise in the river and a break in the coffer-dam. This break occurred near the up-stream outer corner, and was repaired by placing an auxiliary coffer-dam on the outside of the break, and banking outside of that. A sketch (Fig. 1) showing cross-section of this coffer-dam is appended.

Fig. 1.



Scale 1″ = 5′

The repairs commenced on June 27, and were not sufficiently advanced till July 6 to permit pumping to begin. On July 15 excavation was begun in the lock-pit, but the coffer commenced leaking badly on the 17th, and about 75 feet of it gave way on the 18th. This break occurred at the upper end, and the method of repair was the same as before. Repairs were not commenced before the 20th, and pumping not till 7 p. m. on the 25th. Both these breaks were due to carelessness in the construction of the coffer-dam. The contractors were trying to get along cheaply, but found it expensive before they got through.

For instance, on August 2 they had 18 men excavating in the lock-pit, and 22 men repairing leaks; notwithstanding which the dam sprung a leak on that day,and had to be filled. Pumping was resumed at 10 p. m. next day, but the dam was again filled at midnight on August 5, on account of a rise in the river and a leak in the coffer, principally for the latter reason, as the rise was too insignificant to do any harm, had the coffer been built with care. Pumping was resumed in the morning and excavation on the 9th. Work in lock-pit was suspended August 14 by a rise in the river. Pumping was resumed on August 24 and excavation on the 28th.

From an examination made on September 8, when the rock was in good part laid bare at the upper end of the lock-pit, it was determined to omit the concrete, timber, and plank within the lock-chamber below head-walls and above the tail-walls. The bed-rock at the upper end was very slightly scaly on top, and no seams appeared which developed any leaks.

The rock was uncovered at the time of this examination for about 125 feet from the upper end of the lock. Below this several leaks were uncovered, but discharging outside the limits of that portion of the lock chamber where the concrete, &c., was omitted.

The laying of the foundation was begun on September 8. A rise occurred on September 11, and high water prevented work in lock-pit till October 6. Stone masonry

was resumed on the 9th, and the laying of concrete was commenced on the 12th. Wo was suspended in lock-pit on November 21 by a rise in the river.

An attempt was made on the 28th to pump out and resume operations, but a hea snow-storm on the 30th prevented, and the weather becoming cold all work for the s son ended on December 5.

From December 5, 1876, to January 22, 1877, no work was performed at this lock.

The break-up of ice on January 12 did no damage except breaking braces and g lines and letting down the derricks. On January 22d work was resumed in the qu ries, and the pumping of the coffer dam began on February 21, and the laying of maso on the 27th.

The rise on the night of March 9 caused the filling of the coffer and the suspensio work of construction.

Pumping was resumed on May 19, but was suspended on the 21st by a rise. It again resumed on the 25th and masonry was laid on the 28th. A rise on June 12 cau the filling of the coffer. The water receding at once permitted the resumption pumping next day. Masonry was laid on the 15th, 16th, and 17th. On the eve of latter day the coffer-dam was again filled on account of a rise. With this time report closes.

The progress made in construction is as follows:

Land wall. Foundation laid except about 30 feet of first course and about 40 feet second and third courses.

Upper wing-wall, built to 6 feet above miter-sill for 55 feet in length; superstructu of land-wall to reference (2′.0) for about 100 feet, and to reference (6′.0) for 50 feet fr head. [Level of miter-sill is reference (0′.0), from miter-sill to rock about 3½ to 4 fe

Upper gate-chamber. [From cross-sills at head of lock to include cross-sills bel miter-sill] is completed to the level of the miter-sill.

Lower gate-chamber. [From cross-sills above miter-sill to tail of lock] has the upp and lower sills, the pivot-stones, and miter-stone of miter-sill set, requiring concre most of miter-sill and the timber and plank flooring to complete.

River wall. Foundation requires about 50 feet of second course and about 100 feet third course to complete; superstructure is built to reference (6′.0) throughout ho wall and to reference (2′.0) for about 50 feet farther.

DAM NO. 5.

When the last annual report was rendered the excavation for the abutment had be commenced and a tram-road had been graded to the quarry, and the iron nearly la

The excavation for this abutment and the laying of the masonry was perform without a framed coffer, instead of which some of the material excavated was thro on the river side to form an embankment against the water. A comparison with t experience at the lock (No. 5) shows that this method of embanking worked very we the area of excavation being small and near the bank.

The excavation was suspended on August 1 by a rise in the river.

A slide occurred from the bank on the 3d, which filled the excavation made.

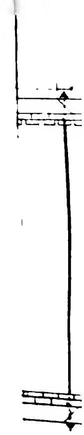
On this latter date excavation was resumed, but was again suspended by the rise August 12. On the 22d it was again resumed. Again suspended by a rise on Septem ber 9. Again resumed on October 5. Masonry was commenced on October 10. Th rise of November 21 suspended work upon masonry, which, with the exception of som work on the 28th and 29th, ended masonry-work for the season. At that time th seventh course above the foundation (reference + 14′.0) had been commenced, th puddling and filling back of the abutment had been carried up to reference (+ 10′.0 and a spur of the dam 38 feet in length was built to the reference (+4′.0).

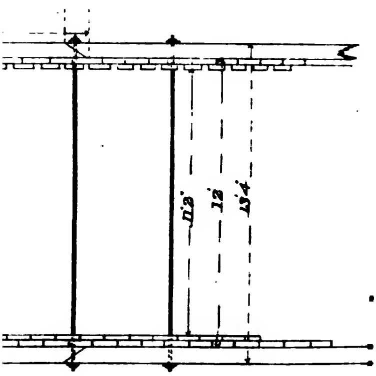
The placing of protection and guy-cribs for the coffer-dam of the central pier wa commenced on July 20, and dredging for the same on September 1. The work upo this coffer-dam has been provokingly slow. At the close of the season of 1876 it ha only been placed and filled to about 3 feet above low water. Plans and sections o this coffer-dam are appended, (sheet No. 3.)

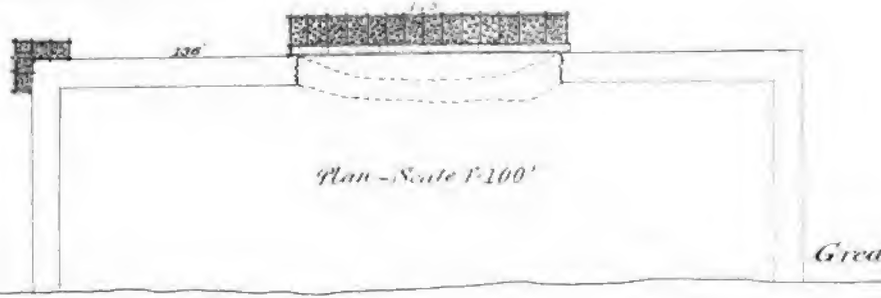
Work in quarries was resumed on January 18. On January 25, as the water wa receding after a rise of 23 feet, a slide of considerable extent occurred from the ban at the abutment excavation. A slide similar to this occurred after the rise in Augu 1876. Sheet No. 4 herewith shows the original section of the bank, together with th sections of the bank both before and after these slides. The slides were due to the in stability of the lower strata, the equilibrium of which was destroyed by the remov of the material at the foot of the slope. It was found that, when the dam was buil the rush of water below the weir would wash out the gravel supporting these stra for some distance down stream, and thereby cause slides dangerous to the work.

To provide against this, it was decided to construct a crib-work down stream fro the abutment, resting upon the rock, the crib-work to be within the line of the abu ment-face. The length of this crib, for the time, is limited to 150 feet, to await ex perience as to whether it be sufficient or not.

The crib has a width of 10 feet and a height of about 9 feet.



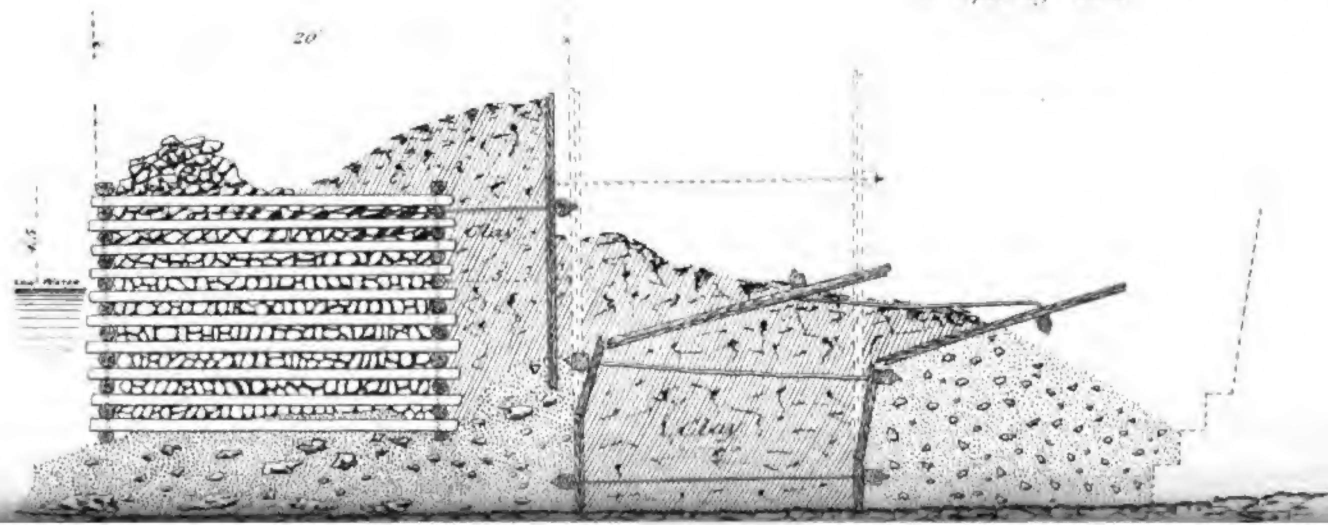

11'2'
12'
13'4'

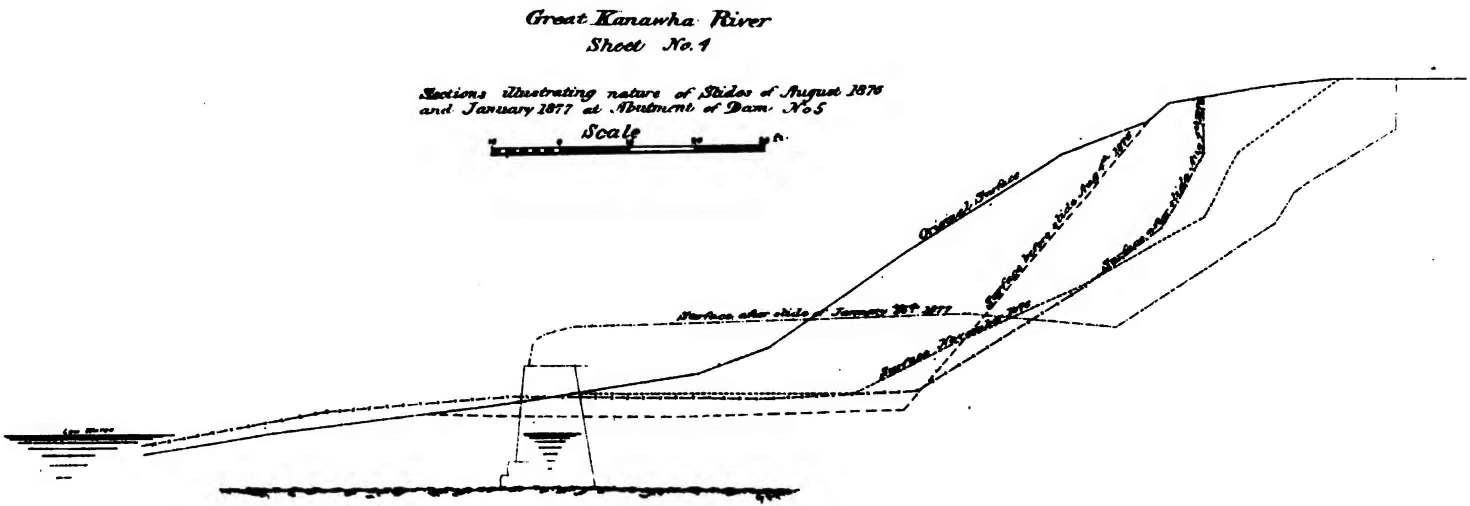


Great Kanawha River

Sheet No 2

Showing break that occurred Dec 21st 1876, in Cofferdam at Lock No 4 and manner of repairing same.




Great Kanawha River
Sheet No. 4
Sections illustrating nature of Slides of August 1876 and January 1877 at Abutment of Dam No 5
Scale
Original Surface
Surface before slide Aug 7th 1876
Surface after slide of January 1877

The removal of the earth from the partially-constructed abutment commenced on February 15, and masonry was resumed on the 28th, and completed to the coping on March 23.

The coping was set complete on April 28. The filling and puddling behind the abutment was carried up with the masonry. The filling above the abutment and the grading of the bank began on April 5, and is now in progress.

The dredging for the crib-work below the abutment began on May 23, and finished June 9. The placing of the crib was commenced on June 13, and on June 16 (the date this report closes) was in progress.

The work on the coffer-dam for the pier has been carried on at intervals.

Pumping was attempted on June 7, but had to be suspended, owing to a leak in the coffer, which necessitated further banking on the outside. The stage of water since has prevented the resumption of pumping.

SURVEYS, ETC.

The survey in progress last year from the head of Lyken's Shoal to Cabin Creek, connecting with last year's line, was completed. A survey was then begun at Ben Franklin Furnace, 9,420 feet below site No. 5, and continued to the foot of Elk Shoal.

A map was begun, on a scale of 1 inch to 200 feet, of the river from the head of Lyken's Shoal to Davies's Creek, nearly 4½ miles below Charleston. This map, which includes about 33 miles of the river, is now entirely plotted in pencil, the portion from Ben Franklin Furnace to the foot of Elk Shoal being complete.

A series of observations for the discharge of the Kanawha above Elk, and of the Elk, were made on January 16, when the Charleston gauge was reading about 35 feet. These observations have not yet been reduced.

All of which is respectfully submitted.

THOMAS TURTLE,
First Lieutenant of Engineers.

Maj. W. P. CRAIGHILL,
Corps of Engineers, U. S. A.

REPORT OF MR. A. M. SCOTT, ASSISTANT ENGINEER.

U. S. IMPROVEMENT OF GREAT KANAWHA RIVER,
Charleston, Kanawha Co., West Va., December 27, 1876.

COLONEL: By direction of Lieutenant Turtle, the following report of operations at Red-House Shoal, during the working season of 1876, is respectfully submitted:

The work was resumed September 14, and completed on the 29th of November, substantially according to the plan approved by your letter to me dated July 5, 1876.

The improvement of the chute at this place was begun in the fall of 1875, and consisted principally in raising and extending the left side-wall, beginning near the head of the shoal. Seven hundred and twenty-five feet of the wall was built in 1875. This season it has been carried down 685 feet farther; 300 feet being built of stone quarried near the work, and the remainder of material dredged from the channel and "banked" on line of the wall. The stone-wall was built to correspond with last year's work; being made 8 feet wide on top, with front and back slopes of ½ to 1 and 2 to 1, respectively, and carried up 6 feet above low-water mark. On the chute side, the stone was roughly hammer-dressed, and laid in offsets.

The top was well secured with large flat stone.

The dredging done below this, besides serving to lengthen the side-wall nearly 400 feet, made quite an improvement by widening and straightening the channel at the foot of the shoal, the material being taken from a heavy gravel and bowlder bar that extended into the chute from 50 to 75 feet past the line of the new wall.

The dredging was done by the Kanawha Board, the Government furnishing hands to grade and shape the material to conform to the wall.

To build the stone-wall, about 630 cubic yards of stone, quarried on the right bank near the foot of the shoal, was used. The work was done by hired labor, at a total cost to the United States of $1,103.22.

The object of the wall, as stated in your last annual report, was to overcome a bad side-current, which was apt to draw tows out of the channel against the old chute-wall or on the bar below. Several quite serious accidents occurred from this cause before the partial improvement was made in 1875. It is thought there will be no more trouble on this account. Several tow-boatmen who have taken out flats since the wall was finished have expressed themselves well pleased with the improvement.

Very respectfully, your obedient servant,

A. M. SCOTT,
Civil Assistant.

Col. WM. P. CRAIGHILL,
Corps of Engineers, U. S. A.

STATISTICS AS TO THE COMMERCIAL IMPORTANCE OF THE IMPROVEMENT OF THE GREAT KANAWHA RIVER, WEST VIRGINIA.

Statement of the principal items of farm-produce, according to the census of 1870.

Counties.	Acres of land.			Total value of farm-products, including betterments and increase of stock.	Wheat.	Rye.	Corn.	Oats.	Buckwheat.
	Improved.	Unimproved.							
		Woodland.	Other unimproved.						
	No.	*No.*	*No.*	*Dolls.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*
Fayette	36,410	5,658	202,375	393,195	14,304	3,003	123,220	41,994	[illegible]
Greenbrier	95,099	170,748	29,740	690,154	50,214	7,734	181,381	92,225	[illegible]
Kanawha	59,459	164,598	7,292	774,582	45,587	728	406,826	96,968	[illegible]
Mason	67,010	86,426	....	654,570	115,200	598	456,990	43,461	[illegible]
Monroe	104,760	164,630	3,429	590,143	52,817	11,320	170,721	59,062	[illegible]
Nicholas	24,455	122,120	36,446	315,854	10,242	1,331	104,300	38,365	[illegible]
Putnam	36,044	74,695	4,644	323,132	30,980	1,340	32,126	49,879	[illegible]
Raleigh	20,969	148,413	....	147,916	7,509	1,660	73,657	16,278	[illegible]

Counties.	Tobacco.	Potatoes.		Flax.	Maple sugar.	Maple molasses.	Sorghum.	Honey.
		Irish.	Sweet.					
	Lbs.	*Bush.*	*Bush.*	*Lbs.*	*Lbs.*	*Gals.*	*Gals.*	*Lbs.*
Fayette	188,165	11,359	3,059	5,036	6,043	....	17,844	[illegible]
Greenbrier	3,176	13,928	78	185	55,740	6,222	1,569	[illegible]
Kanawha	412,409	44,300	7,905	533	459	52	45,367	[illegible]
Mason	58,600	84,534	48	....	200	....	23,762	[illegible]
Monroe	123,321	12,164	443	3,361	42,744	2,629	11,427	[illegible]
Nicholas	840	6,247	....	....	....	....	12,589	[illegible]
Putnam	472,765	26,918	1,172	2,481	626	72	19,511	[illegible]
Raleigh	5,769	6,720	262	2,794	1,745	....	7,163	[illegible]

Statement of live stock, &c., according to the census of 1870.

Counties.	Animals slaughtered or sold for slaughter.	Value of all live stock.	Milch-cows.	Work-oxen.	Other cattle.	Sheep.	Wool.	Butter.	[illegible]
	Dollars.	*Dollars.*	*No.*	*No.*	*No.*	*No.*	*Lbs.*	*Lbs.*	*Tons.*
Fayette	64,504	225,085	2,267	432	2,600	8,709	16,331	72,189	[illegible]
Greenbrier	187,175	553,856	3,201	496	6,703	13,880	34,051	174,863	[illegible]
Kanawha	124,047	413,450	3,400	1,078	4,011	9,879	20,457	163,142	[illegible]
Mason	161,483	514,551	2,332	833	4,350	9,880	22,853	5,002	[illegible]
Monroe	158,460	567,053	3,006	281	6,882	11,317	26,694	163,540	[illegible]
Nicholas	46,567	185,532	1,600	324	3,820	8,171	18,838	164,990	[illegible]
Putnam	70,643	251,049	1,505	813	2,222	6,291	14,992	63,061	[illegible]
Raleigh	21,880	119,184	1,545	274	1,538	5,462	11,358	41,635	[illegible]

TIMBER.

* * * * * * *

Of the hard woods, the white oak is by far the most abundant. It forms one-third, and perhaps one-half, of all the timber in the State, and is one of the most generally diffused trees. In the hilly region of the northern part of the State, between the head-waters of the Cheat and the Ohio, according to Diss. Debar, "it grows on heavy, red clay loams, and in closeness of grain and firmness is unsurpassed. In the whole basin drained by Fishing Creek, Middle Island Creek, Little Kanawha and branches, Sand

Creek, Great Kanawha and those of its branches emptying into it below the falls, and the Guyandotte and Big Sandy Rivers, the oaks, poplar or tulip tree, walnut, cherry, sycamore, ash, chestnut, and locust attain a size not surpassed on the North American continent east of the Rocky Mountains."

To this we may add that the oak, poplar, and chestnut seem to increase in size south of the Great Kanawha. Gigantic poplars are reported reliably from that district 10 and 11 feet in diameter, and oaks 6 and 7 feet.

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On the eastern border of the State, the only development taking place is in the white pine along the Greenbrier River, and this is carried on by a single company.

The Saint Lawrence Boom and Manufacturing Company, controlled by Pennsylvania capitalists, of which Mr. Cecil Clay is president, has a charter for operating the river, and is engaged in improving its navigation. The spring-floods now give them water enough to run rafts of 100 to 150 feet in length.

Logging can be done very cheaply in this country, for the surface is smooth, and supplies for men and forage for teams are abundant around the camps.

The timber region can readily be reached from the Chesapeake and Ohio Railroad from Millborough, Covington, or Ronceverte. This latter place has, according to Mr. Clay, fine natural advantages for the concentration of the lumber business of the Greenbrier Valley. Timber can be had in the river suited for the manufacture of cars, wagons, agricultural implements, furniture, wooden-ware, pump-stocks, and for planing purposes. Lumber can be delivered in Cincinnati so as to compete with the Michigan pine, and in Philadelphia so as to cost less than the Pennsylvania timber. A large market can be had both ways.

The Saint Lawrence Boom and Manufacturing Company has a paid-up capital of $60,000, which is increased as needed, and owns and controls 100,000,000 feet of white-pine timber in Greenbrier and Pocahontas Counties. It has a boom of several millions of feet capacity, and uses splash-dams and tramways in its logging. In times of ordinary prosperity a good business might be done in square timber, oak, &c. Mr. Clay thinks that there are several million dollars worth of timber standing on the Greenbrier River. He says that they are now offered $42 per thousand, Michigan inspection, for timber delivered in Philadelphia.

On the headwaters of the Elk and Gauley nothing has been or is being done to develop that heavily-timbered section. Webster County has sent some logs from her western borders down Elk.

* * * * * * *

A company of enterprising Pennsylvanians, with a capital of $300,000, are now engaged in developing 80,000 acres of land in Braxton and Webster Counties, with saw-mills, planing-mills, and business headquarters at Charleston, on the Great Kanawha. One of the first operations of this company was the shipping by river to Parkersburg, and thence by rail to Baltimore, 10,000 feet of black-walnut plank, which, notwithstanding expensive freight over a distance of 650 miles, yielded a handsome profit.

* * * * * * *

As an illustration of the excellence of the Ohio River timber, we may mention the fact, stated by Mr. C. T. Beall, of Mason, that the brig Somers, distinguished in the Mexican war, was built at the mouth of the Kanawha, by the Gilmores, of Mason County lumber. When this vessel was docked, some eight years ago, her timbers were found to be sound.

* * * * * * *

On the Kanawha River the principal development of timber is from the mouth of Elk downward. Colonel Byrne says of the business on the Kanawha and its tributaries: "Elk River sends out $100,000 worth of logs, cut by mills at and near Charleston, either for use there or for shipment down the river. The white and black oaks are chiefly manufactured into salt-barrel staves, for use in the vicinity of Charleston. The mills there have a capacity of producing 1,000 barrels per day. The poplar, ash, chestnut, walnut, and other kinds are chiefly manufactured into boards, plank, and scantling at Charleston for the Cincinnati and other markets on the river, after supplying the home-market. Besides the logs, Elk sends out a large number of coal-boats ($20,000 worth) for use in shipping coal and salt from the Kanawha River. The manufactured value of Elk River timber, *i. e.*, boards, staves, hoop-poles, &c., is at least $150,000.

"The Great Kanawha, from the falls down, must produce as much lumber in the shape of logs, staves, hoop-poles, boards, and ship-timber as the Elk, or $150,000."

Pocatalico and Coal Rivers contribute largely to this produce of the Lower Kanawha, Pocatalico sending probably $20,000 worth. Coal River sends out some fine walnut, which goes to Europe. The Lower Kanawha sends out some fine oak timber for ship-building, and a good deal of pine. At and near the Falls of the Great Kanawha, and on Laurel Creek, a considerable business is done in cooperage stuff and sawed lumber, perhaps $100,000 worth. Westward to Hinton hardly anything is done. At Hinton a

good deal is done. Some staves are, according to Mr. Clay, floated down from up New River, caught at Hinton, and shipped by rail.

Mr. J. S. Thompsen says of the timber-trade of Hinton: "Quite a large trade is carried on here in the lumber business. Large quantities of pipe-staves of oak are shipped by rail to the East, and several thousand walnut logs have been shipped, both to the eastern markets and to Europe, from the county within the last eighteen months. There is a large saw-mill at this point, owned by New York men, who ship pine (of a fine quality) lumber, also shingles, laths, &c. They deal extensively also in poplar lumber, and furnish the Chesapeake and Ohio Railroad with railroad-ties."

* * * * * * *

THE COAL-FIELD.

The most important coal region in America is the Appalachian coal-field, which is, says Rogers, "almost the largest expanse of continuous coal-measures in the world. It possesses a length of 875 miles, and a maximum breadth between its eastern outcrop in Southern Pennsylvania and its western in Northern Ohio of about 180 miles." It extends from Northern Pennsylvania to Middle Alabama, parallel to the Appalachian Chain to the east of it. Its coals are better than those of any other field in America, and, save anthracite, are of every kind necessary to the arts and manufactures. Its area is made up as follows:

	Square miles.
West Virginia	16,000
Pennsylvania	12,700
Ohio	10,000
Eastern Kentucky	8,900
Alabama	5,000
Tennessee	5,100
Maryland	550
Total	58,250

Of these, the amounts for Pennsylvania and Eastern Kentucky are the results of careful surveys, while the others are estimates taken from the best and latest sources.

By the United States census of 1870, these States mined the following tonnage:

	Tons.
Alabama	11,000
Kentucky	150,000
Maryland	1,819,824
Ohio	2,527,285
Pennsylvania	7,798,518
Tennessee	133,418
West Virginia	608,878
Total	13,048,923

These tables therefore show that while West Virginia embraces (in round numbers) nearly 28 per cent. of the coal-area, it produces only 5 per cent. of the coal mined therein.

* * * * * * *

Let us now examine the number of coal-seams.

To do this so as to be the more fully understood, the coal-strata can be divided into four great geological divisions, viz: The Lower Coal-Measures, resting upon the Great Conglomerate, containing very many important and valuable coal-seams, and having a thick bed of sandstone called the "Mahoning" as its upper limit.

The Lower Barren Measures, composed of reddish and bluish shales and slates, sandstones and limestones—the latter in some parts of the State very important—usually destitute of workable coals, and terminating at the base of a valuable and persistent coal-seam known as the "Pittsburg."

The Upper Coal Measures, containing several important coal-seams, of which the "Pittsburg" is the lowest.

The Upper Barren Measures, composed of sandstones and shales, nearly destitute of coal.

There are geographical divisions in the field that should be noticed, for in several cases ridges parallel to the eastern margin of the basin make their appearance, and are composed of subcarboniferous strata, which separate one coal-basin from another, and form well-marked boundaries thereto.

* * * * * * *

THE NEW AND KANAWHA RIVER COAL-BASINS.

We now come to that district of the State which, by reason of the variety of its coals and number of its seams, is to be considered one of the most valuable portions

of the Appalachian coal-field, and has helped in no little degree to give West Virginia the reputation it enjoys of being one of the richest of the States in the Union in this great element of civilization, wealth, and prosperity. For this reason it has a peculiar interest to the capitalist, while, from a geographical point of view, the great development of the coal-measures is very important.

Going back to a pre-carbonaceous period, it would seem that this section was a deep basin, constantly settling down and being filled up, while the northern portion of the State was nearly stationary.

As an indication of this, it may be noted that the Vespertine formation at Western Port, on the Potomac, is, according to Professor Rogers, 200 feet thick, while in Greenbrier it is 800 feet. In this latter measurement he seems to have taken no notice of some 300 feet of rock that justly belong to its upper portion. In the north, at the same place, the Umbral (or subcarboniferous) limestone is 80 feet, while in the Greenbrier Mountain, in Pocahontas, he gives it as 822 feet. On the Potomac the Umbral shales are 838 feet, versus 1,260 feet in the above-mentioned locality in Pocahontas, and the indications are that all three of these still increase in thickness as we come south toward New River; so that at Hinton they may be taken as aggregating 3,500 feet, versus 1,128 feet in the north.

Continuing on up in the geological column, the Conglomerate is 150 feet thick on the Potomac and on New River, according to Prof. William M. Fontaine 1,350 feet, including the Passage Rocks, while 400 feet takes in the Lower Coal-Measures in the one case and 1,340 feet about embraces them on the Kanawha. Finally, in the north, the Lower Barrens are 400 feet against 700 feet in the south.

By an addition of these figures, and dealing in round numbers, we see that while 2,000 feet of strata were forming on the Potomac or Northern West Virginia, some 6,840 feet were being deposited in the New River and Kanawha region, or, in other words, during this period the latter sank about 4,840 feet more than did the former.

It is to this that we must look for an explanation of the presence of various anticlinal axes in the north and their absence in the south.

As this depression took place the strain or tension of the rock-beds on the eastern border of the basin increased in a direct ratio with the amount of the subsidence, so that the less the latter the less was the former, and it is a self-evident proposition that the less the tension the greater would be the force necessary to break the rocks asunder. Therefore, when the great thrust or press on the strata from the east came into effect, it found the strength of the beds on the eastern border of this southern basin so much impaired that it crushed up the formations adjacent thereto, breaking them into a number of faults of great magnitude, which extend along the southern border of West Virginia and are nearly co-extensive with this depression and its prolongation southward, while in the north the rocks, not being in this very tense state, were not broken, but the Alleghanies and the country to the west were thrown into a series of folds, which become less and less abrupt as they would naturally do the farther and farther we get from the primary force.

The gradation of faults to folds is well seen in the most westerly of the former, which passes just west of Peter's Mountain in the southern part of the State, and is seen near Caldwell's Station, in Greenbrier County, at the Chesapeake and Ohio Railroad trestle over Monroe Branch. In the former place it brings the Silurian rocks against the Vespertine, while in the latter it becomes so small that only the highest members of the Devonian abut against the Vespertine.

From this we can see that as the strata were elevated along this most western fault their flank would raise the country to the west as a whole, and give it a gradual slope at right angles to the line of elevation, and as the latter was northeast and southwest, so the former would be northwest. This is really the case, for from this range on the eastern edge of the Greenbrier to the Ohio River the formations have one continual northwest down grade, save here and there where they become nearly horizontal, and there is no good evidence after we get away from the immediate vicinity of the fault that a single reversal of dip comes in during the whole distance. In the eastern portion of this vast extent of territory, denudation and erosion have carried off the upper strata, and east of Little Sewell all of the Lower Coal-Measures have disappeared.

Going west, the rocks dip faster than the plane of erosion, and thus we get successively into higher and higher strata, so that Gauley Mountain is sufficiently high to catch nearly all of the lower coals.

Below the Kanawha Falls, the dip still continuing, the Conglomerate passes out of view. A short distance west of Charleston the Lower Measures in their turn sink below water-level, and near Pocatalico, some 14 miles farther on, the highest member of the Lower Barrens is lost to sight as it goes beneath the bed of the Kanawha.

Between these extremes of gently inclined formations in the south and folded strata in the north must be an intermediate area, where the one passes into the other.

As the depression of the southern basin became less and less as it went northerly, the tension, and therefore the cause for the faults, diminished, so that somewhere about opposite Huntersville, in Pocahontas, this system begins to cease, and north of a line

drawn from the northeast corner of Greenbrier to the northern part of Pleasants the strata commence to appear in folds, and as we proceed toward the Pennsylvania line and away from the modifying influence of the faulted country, so these anticlinals become more and more marked.

NEW RIVER COALS.

In Mercer County, in the valley of the Blue Stone River, are extensive beds of bituminous coal which would seem to belong to the subconglomerate measures, and are here developed to a greater thickness than in any other portion of the State. The examinations in this county have not been sufficiently in detail to enable us to state the number of the seams, but it may be mentioned that the thickest one reported is 11 feet, although nothing is said as to the amount of clay partings in it.

In Summers County, in the hills on the opposite side of New River from Hinton, a 6-foot seam of coal has been opened some 800 feet above the stream, and indications would seem to point out that it is the same as the seam presently to be spoken of as worked at Quinnimont.

A carefully observed section of the strata on New River was made by Prof. William M. Fontaine, at Quinnimont, and on Piney River, 2 miles below. The observations were begun at the former place at the base of the hill for the sake of obtaining as much as possible of the umbral shales. As the strata dip westerly, Nos. 1 and 2 of these are carried below water-level, so that at Piney the foot of the hill shows only the bottom of No. 3.

The measurements marked "not seen" were obtained from observations elsewhere, or were given by Mr. S. F. Morris, the engineer at Quinnimont.

Umbral shales.

	Feet.
1. Red shales, thinly laminated, visible	50
2. Gray calcareous sandstone	20
3. Variegated shales, with nodules of carbonate of lime near the top	70
Total for umbral	140

Transition strata or passage rocks from the umbral to the conglomerate series.

	Feet.
1. Thinly laminated gray flags and calcareous shales, with impure coal near top	50
2. Black fissile slates and sandstones	20
Total for transition	70

Conglomerate series on Piney.

	Feet.
1. Lower conglomerate	80
2. Black slate with 1¼ foot coal-bed (not seen)	11
3. Olive-colored marlytes passing into olive and reddish sandstones	100
4. Coal and slate 1 ft. 0 in.; Sandstone 8 " 8 "; Coal 0 " 8 "; Slate 2 " 6 "; Coal 0 " 8 "	13
5. Bright red shales and marlytes	30
6. Variegated marlytes	40
7. Ferruginous limestone	2
8. Sandstones	75
9. Coal system with interstratifications of thin coal and slate at base, and on top sandstones, shales, and flags	80
10. Fine gray flags, and sandstones	90
11. Coal, not fully seen	2½
12. Firm gray sandstones	50
13. Olive marlytes	40
14. Coal system at bottom; interstratifications of slate and coal, 1 seam, 1 foot; on top, flags passing into firm sandstones	80
15. Fire-clay and 1-foot coal-seam imperfectly exposed, given as 2 to 4½ feet of impure splint coal	2 to 4½
16. A thick mass of strata not fully exposed at every point; may be divided as follows: (16 *a*) sandstone, 50 feet; (16 *b*) coal-seam not seen, given as 2 feet; (16 *c*) bluish sandy slates, 60 feet; (16 *d*) coal not seen, given as 20 inches; (16 *e*) olive-gray shaly sandstones, 40 feet; total	150
17. Quinnimont coal series, which is made up of splint coal at bottom, 1 foot 2 inches; fire-clay, 2½ feet; semi-bituminous coal, 4 feet; total	7

		Feet.
18.	Dark blue slate and sandstones	80 to 100
19.	Olive-gray sandstones and shales	100
20.	Black slate, with some thin coal	10
21.	Upper or great conglomerate	150 to 200
	Total for conglomerate series	1,195

The coal in No. 20, as seen at Quinnimont, is only 6 inches on the outcrop. In February, 1875, it was opened, and the first 8 feet down increased to 3 feet, and was still improving when this thickness was measured. It cokes well, and when heated in a pipe in a smith's forge gave a clear white bright light in such quantities as to suggest a good gas-coal.

The 4-foot seam of No. 17 is the most important of this section, being the one where the Quinnimont furnace draws its supply of fuel. It is 1,035 feet above New River. The coal is a semi-bituminous, very soft and friable, and makes a most superior coke, not being excelled by even the celebrated Connelsville coke of Pennsylvania. It is also a most excellent steam and domestic article, making a very hot red fire.

The great conglomerate usually forms the tops of the mountains facing New River. As we go back into the country, on each side a second range of hills very soon appears, and in these will be found more coals, which though usually accredited to the conglomerate series, in reality belong to the lower measures. In the vicinity of Raleigh Court-House, southwest of Quinnimont, on Buckly's Mill tract, is seen one of the lower beds of this latter, which measures 6 feet 2 inches, of soft and very pure bituminous coal with shale overhead.

It is seen again on Loup Creek, 15 miles from the court-house, on the Fayetteville road, at McCoy's bank, where it measures 4 feet 10 inches in the breast, and 6 feet on the outcrop. In neither place are there any partings, and it is a most valuable seam, for the most part underlying the whole of the Raleigh plateau. Some distance above this, and about 200 feet below the tops of the hills, at the head of one of the hollows of Big White Stick, occurs a 4½-foot seam, with no parting save about 1¼ inches of coal-dirt, and sulphur 1 or 2 inches from the roof, which is shale. Continuing in a southwest course from here, the Raleigh plateau gives out, and we descend into the valley of the Marshes of Coal, which, cutting far down into the conglomerate series, are marked by an absence of any workable seams, till we cross over to the Guyandotte and Cherry Pond Mountains, on the borders of Wyoming and Boone, in the upper portions of which the Lower Coal Measures and their included seams again make their appearance, and on Gravel Hollow of Peach Tree Creek, near the juncture of the two ranges, four seams belonging to this series have been seen and measured. No. 1, 3 feet; No. 2, 2 feet 8 inches; No. 3, 3 feet 3½ inches; No. 4, 4 feet; all free from partings, and containing an exceeding pure though friable article. The distances between Nos. 1 and 2, and Nos. 3 and 5, are each about 50 feet; that between Nos. 2 and 3 was not ascertained. Several hundred feet above No. 4 and the gaps in the mountains, first a 12-foot and above that a 4-foot seam have been reported.

The deep valley position of the headwaters of Coal River is not fully appreciated, until the observer stands on the mountains last mentioned, where, being some 2,000 feet above the streams below, he has the whole country spread at his feet, and sees that the plateau of Raleigh Court-House forms a high eastern rim of the Marsh Fork Basin, and is far above its level. While looking across this, he can note the country rising into White Oak and Flat-Top Mountains, over which, so great is the elevation of the observer, can be distinguished the blue outline of Peter's Mountain in Virginia.

Passing from this point in a west southwest direction into Wyoming and McDowell the hills become lower than the Guyandotte Mountains, though still high enough to contain not only the conglomerate series but a portion of those above. This country is accredited with seams as thick as 12 feet, but there are no reliable observations to justify more than a mere mention of this fact.

Returning now to Quinnimont and proceeding toward the tier of hills back from the river, the same seams observed in the Raleigh plateau ought to be found. However, as they have never been examined their thickness is a matter of conjecture, but as Big Sewell Mountain has a far greater height than the region immediately to the southwest of the river it will contain a good deal more of the Lower Coal Measures, and hence more seams may be expected.

Continuing northeast into the western part of Nicholas and into Webster the general elevation of the country is below Sewell, consequently the hills contain only lower strata, and the hill-tops west of the forks of Cherry River are made up of the conglomerate, all the upper coals having been denuded off; and on Hominy, Cherry, Cranberry, Williams, and the heads of Gauley and Elk Rivers are to be found only the conglomerate coals, very thin and very unimportant.*

Resuming the northwest line of examination the New River Basin becomes more

*The largest seam that we know of in this region is 3 feet 7 inches. It is seen on Panther Run of Gauley River near the bridle-path from Kentucky to the Promised Land.

shallow, and the strata begin to feel the effects of the dying out of the faults and the beginning of the folds on the eastern border of the State, and we notice that they become more tilted, so that when we reach Rich Mountain, in Randolph, they are very much steeper than when seen on New River.

This line of observation from Wyoming to Randolph has been chosen because it is about the eastern edge of the Lower Coal Measures, while that of the conglomerate series may be said to be a line joining Rich Mountain and Flat Top.

Returning now to Quinnimont the course of observation leads us down New River.

To better appreciate the dip of the strata as we go west I will, whenever possible, refer to the one horizontal line of tide-water, so that it will be plainly seen how any individual stratum becomes lower and lower.

In some cases these figures will not be exact, but very close approximations, not varying more than 15 or 20 feet from reality.

About 16 miles by railroad below Quinnimont, in the hill opposite Dimmock Station, two seams have been exp sed. By aneroid measurement they are 437 and 703 feet, respectively, above New River, and both in the conglomerate series. The first by the side of the path going up the hill is 4½ feet thick, with no partings and a very pure and fine bituminous coal, much harder than the average New River coals. The second one is a few feet above the level of Rush Creek, which mouths at Dimmock, measures 5 feet of clear coal, and was worked by Cary Bibbs.

Twenty miles from Quinnimont, by the railroad, at the mouth of Ephraim's Creek, the following seams were opened by J. A. McGuffin, esq., superintendent of the Longdale Coal and Iron Company.

Estimated height above tide-water.	Heights above New River.		Thickness of seams.	
			Feet.	Inches.
1,020	0	New River level	.....	.....
1,555	535	No. 1 seam	2	0
1,655	645	No. 2 seam	4	0
1,695	675	No. 3 seam	2	6
1,707	687	No. 4 seam	0	5
1,807	787	No. 5 seam	2	6
1,907	887	No. 6 seam	1	0
2,135	1,115	About the top of the great conglomerate	.....	.....
2,185	1,165	No. 7 seam	4	10
2,375	1,355	No. 8 seam	4	6

No. 5 of the table is the seam worked at Quinnimont, but here dwindled to 2½ feet. At that place it is 2,250 feet above tide, while here it is only 1,807, a dip of 443 feet in a straight line of 10 miles, or 44 feet to the mile.

No. 7, the first seam of the Lower Coal Measures, is the only one worked at this place. The mine is about a mile farther down the river and a quarter of a mile above Sewell Depot, and shows at that place an average thickness of 3½ feet, yielding a very soft and tender coal that makes a most excellent coke, which is used by the Longdale Coal and Iron Company in their furnace at Longdale, Alleghany County, Va. The first opening on the seam was at the place noted in the section, but a nipping down of the roof caused an abandonment of the work.

Ten miles below Sewell, at Hawk's Nest, on the land of the Gauley Kanawha Coal Company, the following partial section has been made:

Height above tide-water.	Height above New River.		Thickness of seams.
Feet.	Feet.		Ft. in.
751	0	Level of New River	.....
928	177	No. 1 seam, about	2 0
1,351	600	Top of conglomerate on east side of Mill Creek	.....
1,729	978	No. 2 seam, bituminous	11 0
1,929	1,178	No. 3 seam, splint (?)	3 to 4 feet.
2,079	1,328	No. 4 seam	4 8
2,163	1,412	No. 5 seam, splint and cannel	10 0
2,220	1,469	No. 6 seam	3 6
2,353	1,602	No. 7 seam, splint	9 0
2,363	1,612	Black Flint Ledge	.....

In comparing this with the section at Sewell, the top of the conglomerate falls from 2,135 feet to 1,351 feet, or, as the straight line measured in the dip is between 8 and 9 miles, so the dip will be between 97 and 85 feet per mile. This has brought the conglomerate so low that Gauley Mountain, as it rises above, catches 1,000 feet of the Lower Coal Measures.

Seam No. 1, seen on the railroad going up Mill Creek, is the Quinnimont, that has dipped from an elevation of 2,250 feet, at the place whence it derives its name, to 928 feet at the present point of observation.

Seam No. 2 is the one now operated by the Gauley Kanawha Coal Company at the head of West Lakes Branch, a fork of Mill Creek. It produces a very fine and pure hard bituminous coal, and has four partings in it, measuring 10, 3, 3, and 5 inches respectively. These vary in different parts of the mine, some of them getting thinner as the work is carried to the northwest, till, on the other side of the mountain, the company's engineer reports that the seam shows 9 feet of clear coal in one bench.

Nos. 3, 4, and 6 have not been worked at all. No. 5 was opened for the sake of its cannel, which is of a very poor quality. Beginning at the floor, this seam shows: Coal, 2 feet; slate, 2 inches; coal, 2 feet; slate, 2 inches; coal, 10 inches; slate, 2 feet 10 inches; coal, 2 feet.

No. 7. The opening on this shows magnificent splint, having in it 17 inches of bony or bad coal.

The Black Flint Ledge, which is nearly at the mountain-top, has usually been taken by myself and others as the top of the Lower Coal Measures, which would, therefore, have a thickness of about 1,000 feet.

To do this, however, is wrong, for on the Kanawha, in the vicinity of Paint Creek, at least 200 feet of strata that contain valuable workable beds come above it, and above these appears the Mahoning sandstone, which, 6 miles above Charleston, at Malden,* is 140 feet thick according to Prof. W. B. Rogers, so that to the measurement at Hawk's Nest could be added some 340 feet before the lower barrens would be reached, making the Lower Coal Measures of this country 1,340 feet thick.

In the section given for Hawk's Nest not all of the coals of the Lower Coal Measures are shown, but only those which have been exposed and measured by the company working the property, and these show no less than six workable seams, with an aggregate thickness of 30¼ feet of solid coal, exclusive of partings.

Continuing our observations down New River and into the Kanawha Valley, we see the conglomerate sinking lower and lower till, at Kanawha Falls, it is but a short distance above the stream, leaving all the mountains rising above made up wholly of the Lower Coal Measures; and a short distance below Loup Creek it sinks below the water-level to rise no more until the northwestern margin of the Alleghany basin is reached in the State of Ohio.

THE KANAWHA COALS.

The main body or principal thickness of the lower coals may be said to have their practical eastern margin in Gauley Mountain; far beyond this the strata rapidly rise above the hills and are lost in the air, leaving only the lower seams, as found in the Raleigh plateau and the adjacent country. A line drawn from the mouth of Elk River in a northwest direction passing near the mouth of Big Otter, in Clay County, is the general western boundary, for the Mahoning sandstone comes down to the water-level on or about this course. Throughout the whole of the distance across this a ea are to be found various seams of the very finest qualities of splint, cannel, and bituminous coals. The steep hill-sides readily expose them. The country is cut and countercut in all directions by numerous streams, up which narrow-gauge railroads can be run with the most favorable grades. There are no faults to seriously interfere with the operations of the coal-miner, and the merchant and manufacturer can find every class of fuel, save anthracite, that they may need for the use and comfort of mankind.

In no other part of the Appalachian coal-field are the Lower Coal Measures developed to such an extent, contain a greater number of workable seams, or more varieties of coals, or better or purer fuel.

After leaving Hawk's Nest, the next important disclosure has been made by the Cannelton Coal Company, 9 miles below the Kanawha Falls.

A partial section of the hill shows 7 seams above water-level. Beginning at the river:

Seam No. 1, bituminous coal, is 4 feet thick, but not worked.

*At this place the Mahoning rests on flint, showing that as we come west the intermediate strata give out. Whether the reverse of this is true as we go east toward the Hawk's Nest is not known, as there are no data from which we can reason, for the Mahoning is everywhere above the tops of the hills. In fact, the sections in the vicinity of Paint Creek are not sufficiently in detail to enable us to say if it is found even there, and future observations may show that the strata between it and the flint are even thicker than have been given.

Seam No. 2, some 100 feet above the river, is about 7 feet thick on the average; has two slight partings, and produces a gas-coal of so high a grade as to make it rank one of the most valuable seams of the Kanawha Valley. This same bed is worked just across the river by the Coal Valley Coal Company.

A half mile below Cannelton it is opened again, but not worked, and shows 6 feet 3½ inches, with 3 inches of shale 2 feet from the floor.

Seams Nos. 3 and 4 are seen on the path leading from the old opening on No. 2 to the "Stockton Seam" No. 6. They measure 3½ and 4 feet on the out-crop, and have never been worked.

Seam No. 5 is splint coal 5 feet thick, and not worked.

Seam No. 6 is 8 or 9 feet above No. 5, 750 feet above the river, and 1,350 feet above tide. On an average it is 7 feet thick in the mine, and is made up of cannel coal at the bottom, which averages about 3 feet 6 inches, and is very variable, and a splinty bituminous coal, known in market as "Cannelton Splint," on top. The whole seam is now worked, though for a long time only the cannel was shipped. This and Peytona cannel quote higher in the eastern markets than any other American cannel.

The Black Flint Ledge is 12 to 14 feet above No. 6, or 767 feet above the river, and 1,367 feet above tide.

Seam No. 7 shows 8 feet thick near the mouth of the opening, with 14 inches of slate 10 inches from the floor, leaving 6 feet of clear coal above. This last is a mixture of hard bituminous and splint, yielding a first-class article for steam, domestic wants, and use in the raw state in the blast-furnace.

A recapitulation of these seams shows that there is here above water-level—

	Feet.
No. 1	4
No. 2	7
No. 3	3½
No. 4	4
No. 5	5
No. 6	7
No. 7	8
Total	38½

including the partings, which are small.

Paint Creek empties into the Kanawha, from the south side, 5 miles below Cannelton. In the hill at the mouth of the Left-Hand Fork, about 4 miles from the river, the following section was made in 1873. The height above tide is obtained by allowing Paint Creek a fall of 20 feet per mile, and adding the result for 4 miles to the elevation of the mouth of the creek, which is 570 feet above tide:

Height above tide-water.	Height above the creek.		Thickness of seams.
Feet.	*Feet.*		
650	0	Level of Paint Creek at the mouth of the left-hand fork	
690	40	Seam No. 1	2 feet 6 inches.
702	52	Seam No. 2	3 feet.
713	63	Seam No. 3	2 feet.
742	92	Seam No. 4	3 feet 6 inches.
763	113	Seam No. 5	2 feet.
778	128	Seam No. 6	2 feet.
857	207	Seam No. 7	Out-crop.
892	242	Seam No. 8	Out-crop.
950	300	Seam No. 9	Out-crop.
959	309	Seam No. 10	Out-crop.
997	347	Seam No. 11	Out-crop.
1,020	370	Seam No. 12	2 feet 6 inches.
1,037	377	Seam No. 13	Out-crop.
1,080	420	Seam No. 14	6 feet.
1,113	453	Seam No. 15	3 feet 6 inches.
1,166	506	Seam No. 16	11 feet 4 inches.
1,208	548	Seam No. 17	4 feet.
1,274	614	Seam No. 18	4 feet.
1,285	625	Black Flint Ridge	
1,295	635	Seam No. 19	3 feet 6 inches.
1,317	657	Seam No. 20	2 feet.
1,341	691	Seam No. 21	Out-crop.
1,624	974	Top of hill	
		Total thickness, including partings	51 feet 10 inches.

There are in this 8 seams 3 feet thick and over, measuring 38 feet 10 inches, including the partings that may be present. The next section is made 5 miles below the mouth of Paint Creek, on the land of Col. William Dickinson, opposite Coalburg. It is complete, showing every seam in the hill.

Height above tide-water.	Height above the river.		Thickness of seams.
563	0	Level of Kanawha River.	
589	26	Seam No. 1	4 feet 6 inches.
608½	45½	Seam No. 2	3 feet 0 inches.
626½	63½	Seam No. 3	3 feet 0 inches.
655	92	Seam No. 4	1 feet 0 inches.
685½	122½	Seam No. 5	0 feet 6 inches.
733½	170½	Seam No. 6	3 feet 7 inches.
819	256	Seam No. 7	1 feet 0 inches.
884	321	Seam No. 8	2 feet 0 inches.
955	392	Seam No. 9	5 feet 0 inches.
1,036½	473½	Seam No. 10	2 feet 0 inches.
1,046½	483½	Seam No. 11	4 feet 6 inches.
1,085	522	Seam No. 12	5 feet 6 inches.
1,131	568	Seam No. 13	2 feet 6 inches.
1,145½	582½	Black Flint Ledge	
1,218½	655½	Seam No. 14	3 feet 2 inches.
1,321½	758½	Seam No. 15	15 feet 0 inches.
1,393½	830½	Top of hill.	
		Total thickness of seams	54 feet 3 inches.

The top seam No. 15 shows 4½ feet of coal at the bottom, then 2 feet of slate, 4½ feet of coal, 2 feet of slate, and 2 feet of coal. In mining, the upper 2 feet of slate would most probably be left as the roof, so that this would leave 9 feet of workable coal out of the 15 feet. This, together with the other 8 seams, 3 feet thick and over, and including what partings may be present, gives an aggregate thickness of 41 feet 3 inches.

At Cannelton, seam No. 2 (7 feet thick) is about 667 feet below the Black Flint Ledge, and below No. 2 is a 4-foot seam, (No. 1.) Assuming that this well-marked stratum of flint has this same relative position to the seams below it in the last two sections, (the Dickinson and Paint Creek,) in the Paint Creek measurement the 7-foot seam should be 42 feet below, and in the Dickinson section 85 feet below water-level.

The 4-foot seam is, of course, still lower, but whether these thicknesses continue from Cannelton to the other points only an actual sinking to them can determine.

Synopsis of the sections of the lower coal-measures on the Kanawha and New Rivers.

Locality.	Nature of the sections.	Number of seams over 3 feet thick that have been opened.	Aggregate thickness of seams, including partings.
Hawk's Nest	Partial	6	41 feet 2 inches to 42 feet 2 inches.
Cannelton	Partly above water-level.	7	38 feet 6 inches.
Paint Creek	Complete above water-level.	8	38 feet 10 inches.
Opposite Coalburg	Complete above water-level.	9	41 feet 3 inches.

Other sections could be given, but these are deemed sufficient to show, better than could any words, the great richness of the Lower Coal Measures in this region, and I would call especial attention to the uniformity that exists in the aggregate thickness of workable seams.*

* Taking the specific gravity of coal at 1.3, 40 feet would give 48,000 tons per acre, from which, if even one-third is deducted for partings and waste in mining, there would still be left 32,000 tons per acre, which, at 12½ cents royalty, the common one in the district, would give an income of $4,000 to the owner.

In this connection it is well to state, that as we recede from the Kanawha River toward the head of the many creeks which flow into it from each side, the seams become thicker. I have personally noticed this up Paint and Campbell's Creeks and on Gauley River, 8 or 9 miles from its mouth. But more openings and extended observations will have to be made to enable me to say positively whether this, as a general thing, is so, or whether the increase may not be confined to individual localities. To elucidate such important points as this, is one great argument in favor of the necessity of a careful State geological survey.

From Hawk's Nest to Cannelton (20 miles by river and 10 miles on the dip) the Black Flint Ledge falls 1,000 feet, or about 100 feet per mile. Continuing down the Kanawha, it becomes very much flatter, and in some cases horizontal, until Burning Springs, 21 miles further down the river, is reached, and from that point to where it disappears below the water, (8 miles by road and some 6 miles on the dip,) it once more resumes its slope of 100 feet per mile to the mouth of Elk River, at Charleston. Between these extremes of Gauley Mountain on the east and Charleston on the west, these lower coals have an average width of about 30 miles, and a point a little below the mouth of Paint Creek is about the center of the belt. Drawing a line north 60° east, and south 60° west, receding from each side of the Kanawha into Nicholas, Clay, Braxton, and Webster on the one hand, and Boone, Lincoln, Logan, and Wayne on the other, these vast amounts of coals still continue to be found, and in every direction abundant evidence of them is discovered. Sometimes they form the bed of a stream, or crop out to view in the cliffs and steep mountain-sides; in other places they are exposed by slides on the hills, and are everywhere indicated by the presence of lumps of coal lying smooth and water-worn in the beds of the creeks. Going north 30° west, or south 30° east, from this axis the measures rise in the latter case till they pass into the air above the hills, while in the former they gradually dip below the water-level, and are lost to sight, though shafting will still reach them in many counties where at present they lie untouched.

THE LOWER BARREN MEASURES ON THE KANAWHA.

Of these very little can be said beyond the fact that they have been estimated at 700 feet thick, and probably contain one workable seam of 5 or 6 feet, as seen at the head of Two-Mile Creek of the Kanawha, some 3½ miles from the river. On Elk River, above Clay Court-House, in Clay and Braxton, they become of great importance from the fact they bear several beds of valuable iron-ore, which are now worked by the Elk River Iron and Coal Company.

* * * * * * *

In 1874 the Richmond (Va.) Gas Company tested various coals from the Kanawha Valley with the following results:

Locality.	Bushels tested.	Cubic feet of gas per 2,240 pounds.	Candle power.
Coalburg	951	8,534	14.5
Houston Mining and Manufacturing Company	876	10,281	17
J. B. Lewis & Co	993	9,766	15
Cannelton Coal Company,	1,049	8,892	14
Hampton City Coal Company	609	9,184	15.5
Gordon and Seal	648	8,064	13.9
H. C. Reuler (Coalmont)	1,003	9,699	17.1
Coal Valley Coal Company	....	10,080	17

The coal from the Houston, Coal Valley, and Coalmont mines, is superior to any tested so far; is more free from slate and sulphur, produces greater heat, yields more gas, and makes the best coke.—(Report of Richmond Gas Works, 1875.)

In order better to appreciate these figures, it should be mentioned that the Pennsylvania gas-coal, which is generally adopted as a standard in the United States, gives 9,856 cubic feet of gas, of 14-candle power, per ton of 2,240 pounds.

The coals given in the table are from various localities in the valley, the distance between the extreme eastern and western ones being 15 miles.

The test of Coalburg was on the rich bituminous coal at the bottom of the seam. The main portion of the bed, which is usually called splint, (though in reality a mixture of that and bituminous,) gave, when tested by the Chelsea Gas Company, the remarkable result for this class of fuel of 10,610 cubic feet, of 17½-candle power.

The coal from the Cannelton Coal Company was from the splinty bituminous division of their cannel seam.

The coal from the lower 5 feet 8 inches of the seam of the Coal Valley Coal Company shows

Fixed carbon	61.602
Volatile combustible matter	35.203
Ash	1.873
Moisture	1.322
	100.000
Sulphur in coal	0.658
Sulphur in coke	0.865

Dr. C. M. Cresson analyzed the coal from the same seam from just across the river, from the land of the Cannelton Coal Company, and in his report speaks of it as "a bituminous coal of first-rate quality, and as especially adapted for gas-making. It exceeds in value, for such purposes, the best bituminous coal in use in this or the New York market, by about 7 per cent, and is remarkably free from sulphur."

The 4½ to 5 feet 2 inches seam, at the old Winnefrede mines on Field Creek, in Kanawha County, is bituminous, with 1½ feet of splint at the bottom.

An analysis by Professor Locke, of Cincinnati, shows:

Carbon	68.53
Volatile matter	27.01
Ash	3.22
Water	1.24

An analysis from the laboratory of the Royal School of Mines, in London, of the coal from the 11-foot seam worked by the Gauley Kanawha Coal Company, on Gauley Mountain, in Fayette County, gives:

Coke	65.99
Volatile matter	32.61
Water	1.40
	100.00
Ash	2.15 per cent.
Sulphur	0.74 per cent.

Volatile gas, per ton of 2,240 pounds, 10,100 cubic feet of 17.9-candle power.

Proceeding east from the Gauley Kanawha Coal Company, the hard bituminous coals disappear, and the semi-bituminous come in. They are almost altogether shipped to the eastern market, and in Richmond quote 50 cents per ton of 2,240 pounds higher than the coals from the Richmond fields. They make a most excellent fuel, but their great value is in the admirable coke they produce.

As mined at Sewell Station by the Longdale Coal and Iron Company, it is mostly made into coke for use in the company's furnace at Longdale, in Alleghany County, Virginia, where they succeeded in reducing their fuel bill to a little over 2,200 pounds of coke per ton of pig-metal produced.

At the Nuttallburg mines it is extensively shipped, both raw and coked, the latter being done in open kilns. At Quinnimont it is largely worked by the New River Car Company for use in their furnace on the spot, as well as for shipment. The first of the following tables gives analyses of the coals from these three localities, and the second of the cokes.

In the latter is added, for the sake of comparison, an analysis of a sample composed of 49 different pieces of the celebrated Connellsville coke of Pennsylvania.

Coals.

Mine.	Carbon.	Volatile matter.	Ash.	Sulphur.	Water.	Chemist.
Nuttallburg	69.00	29.59	1.07	0.78	0.34	C. E. Dwight.
Sewell	72.32	21.38	5.27	0.27	1.03	
Quinnimont	75.89	18.19	4.98	....	0.94	J. B. Britton.

Cokes.

Mine.	Carbon.	Volatile matter.	Ash.	Sulphur.	Water.	Chemist.
Nuttallburg	91.22	....	7.53	0.92	....	C. E. Dwight.
Sewell	93.00	....	6.73	0.27	....	
Quinnimont No. 1	93.85	....	6.15	0.30	....	J. B. Britton.
Quinnimont No. 2	91.72	....	5.57	0.48	....	J. B. Britton.
Connellsville	87.46	....	11.33	0.69	....	J. B. Britton.

No. 1 Quinnimont is of the coke made from the coal as usually mined; No. 2 is of the coked slack or mine screenings and refuse. The ash in the Nuttallburg coal and coke shows that the former was either a picked sample, or else that the latter was a poor specimen.

Connellsville coke has obtained so high a reputation, and justly, that there are many persons prone to believe that it can have no superior, and for such it would be well to state that the analyses from Sewell and Quinnimont were made for the private use of the companies using the coal, and that of Nuttallburg was made by the State Board of Centennial Managers.

At various points in the surrounding counties beds of this variety of fuel are found up to 6 feet 2 inches thick, as for instance near Raleigh Court-House. Everywhere that I have examined them they contain the same tender, friable, rich bituminous coal. As far as a physical examination goes—for no analysis has ever been made from this region beyond those given—they are exceedingly pure and would make excellent coke, and the seams have the advantage of being very free from partings.

Returning to the hard bituminous coals of the Kanawha Valley, I have measured very many exposures, varying from 2 to 9 feet, on Gauley, Elk, and Coal Rivers and their tributaries.

In Logan, Lincoln, Wayne, &c., are also many valuable seams, as shown in the following analyses, which are from Wayne County, and, as far as I can learn, all that have been made for the district.

In the table there is no attempt to separate splint from bituminous, the list being given merely to show the general purity of the coals.

Locality.	Fixed carbon.	Volatile matter.	Ash.	Water.	Sulphur in coal.	Sulphur in coke.	Chemist.
Mouth of Camp Creek, of 12 Pole	56.35	37.60	6.05	1.60	0.57	0.14	Wormley.
Stephens, branch of Laurel, of 12 Pole	60.10	36.40	3.50	1.70	0.72	0.18	Wormley.
Tug Fork	61.18	38.74	1.88	......	....	0.02	Taylor.
Tug Fork	60.54	36.66	2.80	......	....	0.03	Taylor.
Cassville	44.89	43.22	10.33	1.56	0.821	....	Dwight.

As showing the thickness of the seams in this portion of the State, the following measurements of outcrops were obtained from a report on the coals of Twelve Pole River by Prof. E. B. Andrews, of the Ohio geological survey:

Locality.	Character of coal.	Thickness of seam.		No. of partings.	Amount of clear coal.		Remarks.
		Feet.	*In.*		*Feet.*	*In.*	
Mouth Camp Creek	Bituminous	6	4	2	5	5	Dry burning and very pure.
Sulphur Spring Creek	Splint	6	0	1	5	8	Excellent quality.
Stephens's, branch of Laurel	Splint	4	9	3	4	5	
William Wiley's, Cove Creek	Splint and cannel.	6	6	......	6	6	Contains 4 feet 6 inches cannel.
Hezekiah's Creek	Splint and cannel.	8	2	2	7	3	Contains 5 feet 6 inches cannel.
Brush Creek	Splint and cannel.	4	1	1	3	10	Contains 2 feet 9 inches cannel.

The coals from all of these are spoken of in the highest terms by Professor Andrews.

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SPLINT-COAL.

Except in a local expansion on one of the seams above the Pittsburg, near Wheeling, there is no well-authenticated instance of this class of coal being found in the Upper Coal-Measures or in the northern half of the State. Possibly this may arise from the fact that the attention of the miner is there mainly directed to gas-coal. Hard, open-burning bituminous fuels exist, but they lack the highly laminated, sonorous characteristics of splint.

Without saying that it occurs nowhere outside of the following limits, the area where it is known positively to exist in workable beds is in the Lower Coal-Measures in Braxton, Webster, Clay, Nicholas, Fayette, Boone, Logan, Lincoln, and Wayne Counties, and its boundaries may be roughly outlined as follows: Beginning at the junction of Louisa and Tug Forks of Big Sandy River, on the Kentucky line, and thence in a straight northwesterly line to the Forks of Coal in Lincoln and Kanawha; thence to Charleston, on the Kanawha; thence to the point where Elk River crosses the Clay and Braxton line; thence bending to the east and running to where the Elk crosses

the Braxton and Webster line; thence southeasterly to the vicinity of Addison, and thence southwesterly, passing through Summersville, in Nicholas, Gauley Mountain, near the Hawk's Nest, in Fayette, the extreme southern corner of Kanawha, and thence on to the common corner of Wayne and Logan, on Tug Fork of Big Sandy. It should be clearly understood that these boundaries are only general, and that instead of being straight, as laid down, they will run in and out in curves, so as in some cases to add to this area and in others to subtract from it.

In this region it is abundant, and in admixture with more or less bituminous coal is ound in seams as thick as 10 and 11 feet. For the combined purpose of steam, domestic use, and the manufacture of iron, it may be looked upon as the most useful and valuable coal of the State; and even now it ranks so high that in the New York retail-market it quotes higher than any other West Virginia coal except cannel. Its value is due to its firmness and solidity, which enables it to be handled, shifted, and stored with very little loss It burns well, leaving but little ash; has both high calorific power and intensity; is usually remarkably free from sulphur (iron pyrites) and other impurities; has little or no tendency to clinker; is free from the danger of firing by spontaneous combustion—a great desideratum in storage and ocean transportation; is first-rate as a steam and household fire, and it has a particular adaptability in the raw state to the manufacture of iron in the blast-furnace, for which purpose it is eagerly sought in districts accessible to market, as it makes a quality of iron which can only be surpased by the use of charcoal.

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As regards practical tests of this coal from West Virginia, the following is about all that has been done:

Mr. Mendenhall, of C. C. Mendenhall & Co., tried it, and speaks of it, under date of October 10, 1867, thus:

"We have thoroughly tested its quality for this purpose (a blast-furnace fuel) in our own furnace, near Wheeling, with the most satisfactory results; regarding it as better adapted to smelting iron than any known coal of the Alleghany coal-field. We used Campbell's Creek and Coalburg coals with about equal results.

"The estimate in which our furnace-manager holds these coals is evidenced from the fact that I am authorized to contract for a supply to be carried up the Ohio River to Wheeling, for use in our furnace there."

Coalburg splint has also been used in the furnaces at Ironton, on the Ohio; but they, as well as Wheeling, stopped their orders several years ago because, on account of the uncertainty of the navigation of the Ohio and Kanawha rivers, they could not get a regular supply and had to keep large stocks on hand.

This stoppage, I should mention, was before the Chesapeake and Ohio Railroad was completed.

The Kenton Furnace, of Newport, Ky., up to 1873, had used some 10,000 tons of Campbell's Creek splint, mixing it with an equal amount of Connellsville coke. Of this mixture it took 1½ tons to make one ton of iron.

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The following table shows the analyses of various West Virginia splint-coals. For the purpose of comparison there is also added the block-coal of Indiana and the Mahoning Valley, Ohio, the Pittsburgh coal, and two of the best iron-making coals of Great Britain.

Locality.	Volatile matter.	Fixed carbon.	Ash.	Water.	Chemist.
Campbell's Creek, Kanawha	35.64	61.07	1.21	1.88	Riverside Iron Company.
Coalburg 4-foot seam, Kanawha	33.26	62.61	1.81	2.14	Riverside Iron Company.
Coalburg main seam. Kanawha	40.50	56.50	1.50	2.00	Levette, Indiana.
Paint Creek Mines, Kanawha	30.13	63.74	6.13	....	Doremus, N. Y.
Kelly's Creek, Kanawha	37.08	60.92	2.00	....	Rogers, Virginia.
Stephens Branch, Wayne	36.40	61.10	3.50	1.70	Wormley, Ohio.
Tug Fork, Wayne	38.74	61.18	1.88	....	Taylor, Ohio.
Tug Fork, Wayne	36.66	60.54	2.80	....	Taylor, Ohio.
Coal Valley Coal Company, upper 16 inches of seam, Fayette.	38.32	57.20	4.30	0.18	Dwight, W. Va.
Briar Hill, Ohio	32.58	62.66	1.16	3.66	Wormley, Ohio.
Star Mine, Indiana	32.50	61.50	2.50	3.50	Levette, Indiana.
Pittsburgh Coal	41.10	56.90	1.00	1.00	Levette, Indiana.
Clyde Splint	36.80	59.00	4.20	....	Musket.
Worsborough, Yorkshire	42.18	60.32	1.50	....	Musket.

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CANNEL-COAL.

Its principal development in West Virginia appears to be in the area assigned to splint-coal, though with more contracted boundary-lines, and in this the thickest exposures yet observed are as follows:

County.	Locality.	Thickness. Ft.	Thickness. In.
Wayne	Laurel branch of Hezekiah, (outcrop)	5	0
Do	Brush Creek, (outcrop)	2	0
Do	Cove Creek, (outcrop)	4	6
Logan	Nine miles of Guyandotte, (outcrop)	3	1
Boone	Workman's branch, (outcrop)	4	6
Do	Peytona Coal Company, lower seam, (average)	3	4
Kanawha	Paint Creek Coal Company, (thickest place)	3	4
Do	Mill Creek Coal Company, (reported)	4 to 5 ft.	
Fayette	Cannelton Coal Company, (average)	3	6
Nicholas	Little Elk of Gauley, (outcrop)	4	0

* * * * * * *

Cannelton cannel, Fayette County, yielded by the treatment of the Union Oil Company 2 gallons per bushel, or 56 gallons per ton. This is really not the full yield, for when the retorts were taken up the present company found there had been considerable waste and leakage. Two companies on Paint Creek, and one on Mill Creek, Kanawha County, formerly distilled oil from this mineral. They were stopped chiefly on account of the war, and have not resumed operations since, partly from lack of capital, but mainly from the discoveries of the cheaper petroleum. There are now no oil-works of this class in operation in the State.

The chief value of this coal is as a gas-producer. For this purpose that from West Virginia has no superior in America. The only two mines in operation within our borders at this date are the Cannelton Coal Company, on the Kanawha, and the Peytona Coal Company, on Coal River. The quotations for their article are higher, without an exception, in all markets that they reach, than any other fuel mined in the United States.

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County.	Locality.	Fixed carbon.	Volatile matter.	Ash.	Cubic feet of gas per 2,240 lbs.	Candle-power.	Chemist.
Boone	Peytona	41.0	46.0	11.0	13,200	32.66	Manhattan Gas-Light Company, New York.
Fayette	Cannelton	23.5	58.0	18.5	1?,025	45.6	Manhattan Gas-Light Company, New York.

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The following tables show the quotations of the chief West Virginia coals in the principal eastern and western markets to which they are carried.

For the sake of comparison their greatest rivals from other States are also added. The prices are taken from the quotations given in the Engineering and Mining Journal on the first Saturday of each of the six months ending April, 1876.

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NEW YORK.

Wholesale per ton of 2,240 pounds, alongside.

Coal.	State.	November.	December.	January.	February.	March.	April.
Westmoreland and Penn	Pennsylvania ..	$6 50	$6 50	$6 50	Not quoted.	$6 00	$6 00
Youghiogheny, Waverly County	Pennsylvania ..	6 50	6 50	6 50		5 75	5 75
Despard	West Virginia ..	6 50	6 50	6 50		6 00	6 00
Murphy's Run	West Virginia ..	6 50	6 50	6 50		6 00	6 00
Fairmont	West Virginia ..	6 50	6 50	6 50		6 00	6 00
Newburg orrel	West Virginia ..	6 50	6 50	6 50		6 00	6 00
Red Bank cannel	Pennsylvania ...	8 50	8 50	8 50		8 50	8 50
Streitsville cannel	Ohio	10 00	10 00	10 00		....	....
Cannelton cannel	West Virginia ..	11 00	11 00	11 00		10 50	10 50
Peytona cannel	West Virginia ..	11 50	11 50	11 00		10 50	10 50
Cannelton sp int	West Virginia ..	6 50	6 50	6 50		6 00	6 00

RICHMOND, VIRGINIA.

Wholesale per ton of 2,240 pounds on shipboard.

Coal.	State.	November.	December.	January.	February.	March.	April.
Kanawha cannel	West Virginia ..	$12 00	$12 00	$12 00	$9 00	$9 00	$9 00
Coalburg splint	West Virginia ..	4 90	4 75	4 75	4 75	4 75	4 75
Lewiston splint	West Virginia ..	4 90	4 75	4 75	4 75	4 75	4 75
Kanawha gas	West Virginia ..	4 50	4 50	4 50	4 50	4 50	4 50
New River bituminous	West Virginia ..	4 50	4 50	4 50	4 50	4 50	4 50
Clover Hill, James River	Virginia	4 25	4 25	4 25	4 00	4 00	4 00
Bituminous	Virginia	3 30	3 30	3 30	3 30	3 30	3 30

CINCINNATI, OHIO.

Wholesale per bushel, afloat.

Coal.	State.	November.	December.	January.	February.	March.	April.
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*
Youghiogheny	Pennsylvania	10	10	9	7½	7½	7½
Pittsburgh	Pennsylvania	10	10	9	7½	7½	7½
Pomeroy	Ohio	8	8	6	5	5	[illegible]
Kanawha	West Virginia	10	10	10	7½	7½	7½

LOUISVILLE, KENTUCKY.

Retail per bushel.

Coal.	State.	November.	December.	January.	February.	March.	April.
		Cents.	*Cents.*	*Cents.*	*Cents.*	*Cents*	*Cents.*
Pittsburgh	Pennsylvania	14	14	14	14	14	12
Raymond City	West Virginia	13	13	13	13	13	11
Pine Hill	Kentucky	13	13	13	13	13	13
Peytona cannel	West Virginia	20 to 22	20 to 22	20 to 22	20 to 22	20 to 22	20 to 22

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IRON.

Kanawha County.—As far as examinations have gone, only the northwestern half of this county can lay claim to iron-ore. Those exposures that have been observed are, a 2-foot bed in the hills across Elk River, opposite Charleston, from which the Kanawha Iron Company, whose furnace is now building, expects to draw a portion of its supplies; a bed 2 feet 2 inches thick 1¼ miles up Campbell's Creek, of a brown oxide, lying just above the Black Flint Ledge. It has, however, a good deal of sand in it, and would have to be mixed with other and richer ores for furnace use.

A seam on the Davis Creek side of the dividing ridge between that stream and Rush Creek was opened some 15 or 20 years ago with the intention of starting a small furnace, but the idea was abandoned. It is 2½ feet thick according to the recollection of General L. Ruffner, and is on the Black Flint. It is, therefore, the same bed as the last.

The ore that is still lying about is a siliceous brown oxide containing some 30 or 35 per cent. of iron. It would mix well with the richer ores of Virginia. Lower down Davis Creek several workable seams of carbonate of iron or the results of its decomposition are reported, an analysis by O. N. Stoddard, of Worcester University, Ohio, of one 80 feet above the Mahoning sandstone, giving—

Iron	34.927
Carbonate lime	9.400
Carbonate magnesia	2.450
Siliceous matter	15.400
Alumina	4.210
Manganese	2.900
Sulphur	0.243
Loss of water by drying	0.400
Loss of combined matter by ignition	27.800
Loss	2.270
	100.000

This shows that after the ore is roasted and the 28.2 per cent. of water and combined matter are driven off, the remaining mass will contain 48.6 per cent. of metallic iron.

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Greenbrier County.—On Howard's Creek, within 4 or 5 miles of the White Sulphur Springs, iron-ore of fair quality and apparently in large quantities has lately been discovered, and on Anthony's Creek the fossiliferous and block ores make their appearance. At the point of observation the fossil ore was 9 inches thick, but the block ore has been opened at two places, each showing 7 feet.

It inclines at a good angle for mining. A bluff ore also shows itself at numerous points in large masses. (Report of T. S. Ridgeway on the minerals along the Chesapeake and Ohio Railroad.) Analyses of several of these ores, by J. B. Britton, show:

Fossil ore	52.23 per cent. iron.
Pipe	61.75 per cent. iron.
Hematite ore	57.17 per cent. iron.
Bluff ore	36.69 per cent. iron.

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SALT.

CHARLESTON, W. VA., *April* 5, 1876.

DEAR SIR: In compliance with your request, I send you herewith some facts in regard to the early history, subsequent developments, and present condition of the salt manufacture and salt interest of Kanawha and Mason Counties, and of West Virginia generally.

Hoping that the paper may in some degree furnish the information you desire,

I am, very respectfully, yours, truly,

J. P. HALE.

Prof. M. F. MAURY.

Rich as is West Virginia in coal, iron, timber, &c., she is scarcely less rich in that indispensable necessity to human health and comfort and to animal life, common salt. Fossil or rock-salt has not been found in the State, but salt brines of greater or less strength and in greater or less abundance are found by artesian borings at greater or less depth throughout the Appalachian coal-field, which underlies the greater portion of our State.

The strength of these brines varies in different localities, and in different wells in the same locality; the range may be stated at say 6° to 12° by the salometer, Baume scale, (distilled water being 0°, saturation 25°,) but the average strength of the brines

from which salt is now made is about 8° to 10°. The value of these brines depends of course upon their location as regards accessibility and cheap transportation of the products to market, as well as the convenient proximity of cheap coal for fuel and timber for barrels.

Only locations on the navigable rivers or lines of railways at present fulfill these indications, but as population increa-es, and new routes of travel and traffic are opened up, it is probable that new salt-manufacturing localities will be developed.

The principal points at which salt has been manufactured in the State are Charleston, on the Great Kanawha River, from West Columbia to Hartford City, on the Ohio River; at Bulltown, on the Little Kanawha; at Louisa, on the Big Sandy; in Mercer County, on New River; near Birch, of Elk River, (at the mouth of Otter Creek on Elk, Authors,) and at a few other less important points, on a very small scale, for local use. At present, owing to the greater facility of reaching the markets of the great West by cheap water-transportation and the advantages of cheap fuel, salt is only manufactured on a commercial scale near Charleston, on the Great Kanawha, and in Mason County on the Ohio.

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Salt-works, Mason County, West Virginia.

Name of furnace.	Capacity.	Depth of wells.	Owners' names.
	Bushels.	*Feet.*	
New Haven	300,000	1,200	Hartford City Coal and Salt Company, 1,100 acres of coal-land.
Hartford City	300,000	1,150.60	
Star	325,000	1,150.60	
Valley City	350,000	1,125.35	Valley City Coal and Salt Company.
Jackson	200,000	1,120.30	V. B. Horton, jr.
German	250,000	1,120.30	German Salt Company.
Hope	350,000	1,120.30	Hope Salt Company.
Mason City	325,000	1,120.30	Mason City Salt Company.
Bedford	300,000	1,150	Bedford Salt Company.
Clifton	300,000	1,150	Not running.
Burnup, or Quaker City	150,000	1,150	Not running.
New Castle	250,000	1,155	Not running.
West Columbia	300,000	1,125.40	Not running.
Actual capacity	3,700,000		
Actually made in 1875	2,500,000		

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The Kanawha salt-works are situated in Kanawha County on the Kanawha River commencing about 3 miles above Charleston and extending up the river for several miles on both sides.

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From the 2,000 or 3,000 or 4,000 bushels per month of the earlier furnaces, the production has been increased to 20,000, 30,000 or 40,000 bushels per month. The writer's furnace, Snow Hill, has made in one year, independent of all stoppages, delays, &c., 420,000 bushels, the largest single month's run being 41,000 bushels. This furnace has 20,000 square feet of evaporating cistern-surface, and over 1,300 square feet of metal-pan furnace-surface. About 1,200 bushels of coal per day are consumed in the furnace proper and about 300 more for engines, houses, and other purposes.

How far this will be exceeded in the future remains to be seen. The same progress has occurred in freighting salt as in the manufacture.

In the days of Elisha Brooks, the neighbors took the salt from the kettles in their pocket handkerchiefs, tin-buckets, or pillow-cases. Later, it was taken in meal-bags, on pack-horses and pack-saddles.

The first shipment west by river was in 1808, in tubs, boxes, and hogsheads, floated on a raft of logs. Next came small flat-boats, 50 to 75 feet long and 10 to 18 feet wide, run by hand, and in which salt was shipped in barrels. These boats increased in size up to 160 feet or more long and 24 to 25 feet wide, and carried 1,800 to 2,200 barrels of salt.

These boats were all run by hand, at a great risk, and although the Kanawha boatmen were the best in the world, the boats and cargoes were not unfrequently sunk, entailing heavy loss upon the owners of the salt. The late Col. Andrew Donnally used to ask, when he heard of one of his boats sinking, whether any of the boatmen were drowned; if not, he contended it was not a fair sink. But all this is now done away with. Salt is now shipped eastward by rail, and to the nearer westward markets

by daily and weekly steamboat packets, and to the most distant markets by tow-boats and barges. A tow-boat will now take 8,000 to 15,000 barrels at a trip, landing them at Louisville, Evansville, Nashville, Memphis, Saint Louis, or elsewhere.

In the matter of packages, no change has occurred here since the first use of barrels, the principal change being a gradual improvement in the quality of the cooperage. Our neighbors in Mason County ship some salt in bulk and some in bags, but the larger portion in barrels. Kanawha uses barrels exclusively.

We use two sizes, 280 pounds and 350 pounds, net salt, respectively.

The pork-packing trade takes the larger size, and the retail trade the smaller, chiefly.

These barrels are made of white-oak staves and hickory hoops, and it is believed that nothing cheaper or better can be devised for salt packages.

They are cheaper than bags, more convenient to handle, more convenient to store, stand rougher usages, and more exposure to the weather. Markets having choice of salt in bags or barrels generally prefer the barrels.

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The cost of manufacturing salt on the Kanawha varies, of course, from time to time, with the varying price of living, labor, and supplies. It also varies with the particular furnace, according to size and the greater or less advantages which it possesses. The larger the furnace, other things being equal, the cheaper it will make salt. The general superintendence and management of a large furnace costs very little, if any, more than for a small one, and a given quantity of coal will make more salt on a large furnace than a small one.

The best furnace will make 100 bushels of salt with 80 to 90 bushels of coal. A good average result is a bushel of salt for a bushel of coal, and the least economical consume about 125 bushels of coal per 100 bushels of salt.

Some of the furnaces mine their own coal, and some buy fine or nut coal from mines that are shipping coal. Even the best furnaces do not use coal at all economically or to the best advantage. There is in this respect great room for improvement.

The cost of coal, delivered at the furnaces, ranges from 2½ to 4 cents per bushel. The present cost of barrels is 25 to 28 cents for the smaller size and 28 to 32 cents for the larger. The cost of common day-labor is $1 to $1.25 per day. Coal-miners get 2 cents per bushel.

The cost of producing salt at these figures may be stated at 8 to 11 cents per bushel in bulk, or 13 to 16 cents in barrels, ready for shipment.

The present cost of boring a salt-well here, say, 1,000 feet, after engine, well-frame, &c., are ready, is $1,200 to $1,500. The time necessary to bore and ream it complete is 60 to 90 days. The cost of a salt-furnace complete depends upon size, &c., and varies within wide limits. It may be stated roughly at $40,000 to $100,000.

The people of the United States consume more salt than those of any other country, the estimated average consumption being one bushel of 50 pounds *per capita* for the entire population.

The great western markets, where our product goes, consume even more largely than the general average. as this is the largest pork-packing region on the globe. This portion of the country is rapidly increasing in population and as rapidly in its meat-crop and salt-consumption.

It is well known to chemists that salt is a valuable fertilizer on most soils for wheat, cotton, grass, potatoes, turnips, and other crops; and as an ingredient in compound manure it has a wide range of value. It is often recommended by the highest authorities, but as yet very little is so used in this country. When agriculture gets to be better understood and practiced, and agricultural people understand their interests better, a large demand and consumption will doubtless be developed in that direction.

The most important and prospectively promising development in the manufacture of salt here is its probable use on a large scale in the manufacture of alkalies and other chemicals having salt as a basis or important constituent.

With a population of 40,000,000, and covering the greater part of a continent, it is an astonishing fact that our last census does not report a single soda-ash works in operation in the United States, while the official returns show the importation of these chemicals into the country to be enormously large.

In 1872 the importation of soda-ash, caustic soda, &c., was over 100,000 tons; in 1873, 118,000 tons; in 1874, 140,000 tons; in 1875, —— tons.

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All, or nearly all, of our supply of these chemicals comes from Great Britain. Official reports of 1870, giving the operations of 1869, will give an idea of the extent and importance of the manufacture in that country.

In that year the manufactories there consumed 10,184,000 bushels of salt; 26,908,000 bushels, or 961,000 tons, of coal; 281,000 tons of limestone and chalk; 264,000 tons of pyrites; 8,300 tons of nitrate of soda, and 33,000 tons of timber for casks.

The manufacture, I am told, has largely increased since 1869, but I have not seen official reports of a later date.

Is there any sufficient reason why this manufacture should be so neglected and ig-

nered in this country? On the contrary, the advantages are so great and so palpable, that it is difficult to understand why capital and enterprise have not been enlisted in it. To illustrate, compare the conditions of manufacture at Newcastle-on-the-Tyne, the seat of the largest manufacture in England, and what they would be on the Kanawha.

The Newcastle manufacturer buys his salt in Cheshire, and transports it several hundred miles by rail. He buys his coal from neighboring collieries, paying railway transportation on that to his works. His pyrites and manganese come from Spain, and his timber for casks from Canada or Norway.

When the chemicals are made, he sends them to Liverpool or Glasgow by rail for American shipment, thence by steamers to New York, paying ocean freight, insurance, and Government duty. At New York he pays commission, cartage, &c., and thence railroad freight to the western markets, say to Pittsburgh, Saint Louis, &c.

Per contra, the Kanawha manufacturer would have salt and coal at his doors, at a small margin over producer's cost, if he did not produce them himself at actual cost. On the line of the Chesapeake and Ohio Railroad, accessible, cheap, and convenient, are inexhaustible mines and beds of superior pyrites, manganese, and limestone, and timber of the finest qualities abounds throughout the region and is extremely cheap.

The product, when ready, could be rolled from one door of the factory into boats or barges, and in a short time, by cheap water-transportation, be landed at these same large western consuming markets from Pittsburg to Saint Louis, inclusive, or from the opposite door of the factory, on the cars of the Chesapeake and Ohio Railroad, for early delivery into any of the eastern cities.

It will be readily seen, I think, that the advantages are greatly in favor of the American manufacture, and especially at Kanawha, where there are probably more advantages combined than at any other point in the country.

With cheap salt, cheap coal, cheap sulphurets, cheap manganese, cheap limestone, cheap timber, cheap labor, and cheap transportation, there is nothing lacking but capital to make the Kanawha the Tyne of America. West Virginia should at least supply soda-ash, caustic-soda, and bleaching-powder to the great chemical-consuming markets of the West, so near and cheaply accessible to us, if not indeed to the whole continent, thus saving to the consumers millions of dollars of extra cost for the foreign article.

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Glass-works, soap-factories, paper-mills, &c., might with advantage be located here convenient to salt and chemical supplies. The products of these establishments would, of course, have the same advantages of cheaply reaching the great consuming and rapidly-growing markets of the West.

The Great Kanawha coal-field, within which lies the Kanawha salt basin, is one of the finest known coal-fields in the world. We have coal of the finest qualities—splint, bituminous, and cannel; hard-block coal, suitable for iron-making; soft, rich coal for gas; good coking-coal, steam coal, and grate-coal. Our cannel-coals, for parlor use or gas-making, are unexcelled. Iron-ores, carbonates of the coal formation, are found throughout the region; red and brown hema ites and specular ores are cheaply accessible by rail; and black land of a superior quality is found here in large abundance.

As a timber region, especially for the hard woods, this can hardly be excelled on the continent.

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The distinctive characteristics of Kanawha salt may be stated as follows:

1. It has a more lively, pungent, and pleasant taste, as a table-salt, than any other known.

2. It is the only commercial salt that is absolutely free from sulphate of lime.

3. It does not, under any conditions of climate and weather, cake or crust on the surface of the meat, but penetrates it and cures it thoroughly to the bone, so that in large pork-packing establishments in Cincinnati and elsewhere it is found to save meat in very unfavorable weather, where with any other salt known or used the meat would have been injured.

4. On account of its pungency and penetrating qualities a less quantity of it will suffice for any of the purposes for which it is used, whether table, dairy, grazing, or packing.

Certificates from numerous western firms show that the Mason County salt quotes with this, though at the same price consumers prefer that from the Kanawha wells.

There are in this salt district about 120 salt-wells, all told. Some of these, being inferior, have been abandoned, and will probably never be used again. Others are good wells, the furnaces connected with which have been dismantled by "dead-rents" or other causes. These furnaces may be rebuilt and restarted.

The good wells, if all run, would supply brine for about 5,000,000 bushels of salt per year. Each furnace requires 3 to 5 wells.

There are at present 10 furnaces here, of which the following is a list, with name of owner and capacity.

The aggregate capacity is about 2,500,000 bushels per year, if all were run full time. Two of the furnaces, however, are not in repair, and some others that had been idle have only recently been repaired, so that the product of 1875 was very small.

List of Kanawha salt-furnaces.

Name of furnace.	Name of owner.	Productive capacity.	Remarks.
		Bushels.	
Daniel Boone	W. B. Brooks	300,000	
Crittenden	W. D. Shrewsberry	280,000	Not in repair.
Snow Hill	J. P. Hale	420,000	
Washington	J. D. Lewis	230,000	Not in repair.
Pioneer	General L. Ruffner	180,000	
Quincy	J. Q. Dickinson	210,000	
Burning Spring	Mrs. R. Tompkins	160,000	
Alden	Mrs. S. Dickinson	240,000	
Lorena	Splint Coal Company	240,000	
Kenton	Splint Coal Company	240,000	
Total		2,500,000	

Statement showing the production of salt in Kanawha.

Date.	Bushels per year.	Date.	Bushels per year.
1797	(*)	1850	3,142,100
1808	(†)	1851	2,862,676
1814	600,000	1852	2,741,570
1827	787,000	1853	2,729,910
1828	863,542	1854	2,233,868
1829	989,758	1855	1,493,548
1830	906,132	1856	1,264,049
1831	956,814	1857	1,266,749
1832	1,029,207	1858	
1833	1,288,873	1859	
1834	1,702,956	1860	No records.
1835	1,960,583	1861	
1836	1,762,410	1862	
1837	1,880,415	1863	
1838	1,811,076	1864	1,300,991
1839	1,593,217	1865	861,973
1840	1,419,205	1866	1,275,017
1841	1,443,645	1867	1,321,066
1842	1,919,389	1868	1,528,249
1843	2,197,887	1869	1,822,430
1844	1,874,919	1870	1,721,963
1845	2,578,499	1871	
1846	3,224,786	1872	No records.
1847	2,690,087	1873	
1848	2,876,010	1874	
1849	2,951,492	1875	967,465

* 150 pounds per day. † 25 bushels per day.

CHRONOLOGICAL LIST OF EVENTS AND INCIDENTS CONNECTED WITH THE KANAWHA SALT INTEREST.

1753.—Indians made salt at the Kanawha salt-springs. Reported by Mrs. Mary Ingles, then a captive.

1774.—Walter Kelley and family first white settlers in Kanawha Valley.

1775.—General Washington reserved from his lands and gave to the public the Kanawha Burning Spring.

1785.—John Dickenson "located" the Kanawha salt-springs.

1790.—(Before and after.) Daniel Boone lived here opposite the salt-spring.

1794.—Joseph Ruffner purchased the salt-spring, and in 1795 moved to Kanawha.

1797.—Elisha Brooks put up a kettle-furnace, made 150 pounds of salt per day, and sold it at 8 to 10 cents per pound.

1806.—David and Joseph Ruffner commenced to bore the first salt-well.

1808.—Some parties started their kettle-furnace, made 25 bushels per day, and sold it for 4 cents per pound.

1808.—William Whittaker, Tobias Ruffner, Andrew Donnelly, and others, followed, boring wells and building furnaces.
1808.—First salt shipped west by river in tubs and boxes on a log-raft and in canoes.
1810-'12.—The late Tom Ewing, of Ohio, boiled salt and studied law and Latin here.
1815.—First gas-well struck by Captain James Wilson.
1816.—First steamboat ever in Kanawha, called the Eliza.
1817.—Coal first used in salt-making.
1817.—The first Kanawha salt company, "Steele, Donnally & Steele."
1822.—Highest water ever known in Kanawha to that time.
1822.—Second salt company, "William & Robert M. Steele."
1827.—Lewis Ruffner and Frederick Brooks introduced the first steam-engine to pump salt-water.
1827.—Third salt company, "Armstrong, Grant & Co."
1830.—F. Brooks laid the first wooden tramway to haul coal.
1831.—Billy Morris invented the "slips."
1833.—Fourth salt company, "Donnally, Beam & Co."
1834.—Col. B. H. Smith brought from the Norfolk navy-yard model for keyed-clamped cistern.
1835.—George Patrick invented steam evaporation in salt-making.
1835.—Lewis Ruffner built the first keyed cistern (20 by 7 feet) and put a cast-iron pipe through it.
1836.—Fifth salt company, "Hewitt, Ruffner & Co."
1841.—John D. Lewis first used steam under copper pans for making salt.
1841.—Frederick Brooks first used copper pipes and steam through cisterns.
1843.—Big Burning Spring gas-well struck.
1849.—Williams and Stevens bored and built first furnace on the Ohio.
1851.—Sixth salt company, "Ruffner, Donnally & Co."
1856.—Seventh salt company, "Ruffner, Hale & Co."
1856.—Lowest water ever known on the Kanawha and Ohio rivers.
1856-'7.—Coldest winter and longest freeze-up ever known here.
1861.—Disastrous flood in river; the highest water ever known here.
1861-'5.—War.
1864.—Eighth salt company, "Kanawha Salt Company."
1872.—The Chesapeake and Ohio Railroad opened.
1875.—The ninth and present salt company, "The Kanawha Salt Company," organized.
1875.—United States Government commenced to improve the Kanawha River by locks and dams.

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Limestone, common.

County.	Locality.	Carbonate of lime.	Carbonate of magnesia.	Alumina and oxide of iron.	Insoluble siliceous matter.	Water and loss.	Chemist.
Greenbrier	Fort Spring	90.11	2.49	2.02	5.04	0.34	J. B. Britton.
Do	On C. & O. R. R	93.76	0.29	1.12	3.92	0.91	C. E. Dwight.
Do	Blue Sulphur Springs	98.20	0.00	0.48	0.40	0.92	W. B. Rogers.
Do	Muddy Creek Mountains	88.64	9.60	0.12	0.20	0.44	Do.

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In Greenbrier County, near Ronceverte, large deposits of an extremely hard, durable, and handsome sandstone occur. One is of a gray color, and was largely quarried and boated six miles down the Greenbrier River to build the piers, &c., of the railroad-bridge over that stream—the contractors preferring to do this to using the stone nearer at hand. The other is of a chocolate color, and has a local use for building purposes.

On the upper portion of the Kanawha River the sandstones of the Lower Coal-Measures furnish the materials for the locks and dams now being built by the United States Government; and from the various hills along its line the Chesapeake and Ohio Railroad obtained the stone for the construction of its bridges, culverts, &c.; while the Mahoning sandstone at Charleston furnishes a beautiful gray and easily-wrought trimming for many of the houses of that city.

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In Greenbrier County, near Alvon, on Anthony's Creek, a blue variety of excellent quality is found.

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SALTPETER

Is to be found mingled with the earth in many of the caves of the limestone region of Greenbrier, Monroe, and Pocahontas, and in the first-named county has been procured from time to time in considerable quantities from this source.

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MINERAL WATERS.

West Virginia comprises within her southern and southeastern border a large portion of the celebrated mineral-spring plaza, long known as the "spring region of Virginia," and which for the last eighty or ninety years has been greatly resorted to by the seekers of health and pleasure of every great section of the United States.

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White Sulphur Springs.—The White Sulphur Springs, so long famous among the mineral waters of the world, are in the county of Greenbrier, 5 miles west of the crest of the Alleghany Mountains.

The Red Sulphur Springs, in the county of Monroe, 40 miles south from the White Sulphur, have been known and distinguished as a watering-place for more than 60 years.

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The Salt Sulphur Springs, near Union, in Monroe County, afford a valuable mineral-water.

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In addition to the springs already mentioned, there are in various parts of the State, indeed in every great section of it, mineral-fountains that are well worthy of public attention.

Among these are the Blue Sulphur Springs, in Greenbrier County, once a place of much resort and an excellent mineral-water, and Guinn's Springs, in Fayette County, near the mouth of Lick Creek.

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TRANSPORTATION.

The following are some of the transportation companies now in operation:

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Chesapeake and Ohio Railroad.—In the southern part of the State, with its eastern terminus on tide-water at Richmond, Va., and its western at Huntington, on the Ohio River. It passes through the counties of Greenbrier, Monroe, Summers, Fayette, Kanawha, Putnam, and Cabell, having as its principal stations the White Sulphur Springs, Lewisburg, with Ronceverte as the depot, 3 miles distant; Quinnimont Furnace, Kanawha Falls, Coalburg, Charleston, Saint Albans, Barboursville, and Huntington, whence it is 160 miles by the Ohio River to Cincinnati.

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Coal River Railroad Company.—To build a railroad from Saint Albans, in Kanawha County, up Coal River to the junction of the Marsh and Clear Forks, in Raleigh County, to have a branch running up Little Coal River to Boone Court-House. *Objects:* To develop the mineral and timber resources of Coal River.

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Gauley River Railroad Company.—To build a railroad from the mouth to the head of Gauley River, passing through Fayette, Nicholas, and Webster, into Pocahontas. *Objects:* To develop the mineral and timber resources of Gauley River.

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New River Railroad, Mining, and Manufacturing Company.—To build a railroad from the Chesapeake and Ohio Railroad, at the mouth of Greenbrier River, up New River to the State line.

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Paint Creek Railroad Company.—To build a railroad from the Chesapeake and Ohio Railroad, at the mouth of Paint Creek, up that stream, in Kanawha and Fayette Counties. *Objects:* To develop the coal interests of Paint Creek.

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West Virginia Railroad Company.—Beginning at or near the mouth of the Big Sandy River, in Wayne County, their railroad will run thence in an easterly direction to the Kanawha River, near Saint Albans, in Kanawha County; thence to Charleston, at the mouth of Elk River; thence up that stream for 150 miles; thence northeasterly to the South Branch of the Potomac; and thence down the same to its mouth, passing through the counties of Wayne, Cabell, Putnam, Kanawha, Clay, Braxton, Webster, Randolph, Pendleton, Grant, Hardy, Hampshire, and Morgan.

West Virginia Central Railroad Company.—From Charleston, their railroad will run up the Kanawha; thence up Gauley to its head; and thence through Pocahontas County to Harrisonburg in Virginia, passing through the counties of Kanawha, Fayette, Nicholas, Webster, and Pocahontas.

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Great Kanawha River is navigable all the year round, except in exceptional cases, when navigation is impeded by ice, from the Ohio to Brownstown, a distance of 70 miles. In a good stage of water we can go up to Loup Creek, 22 miles higher. In low-water only the smaller classes of boats can run. In order to give the enormous mineral interests of this stream a free exit to the Ohio all the year, the United States Government is now locking and damming it so that 6 feet of water can always be expected. From Malden, 6 miles above Charleston, there is a weekly line of boats to Cincinnati and a daily line to Gallipolis, on the Ohio, and tri-weekly connections with Parkersburg and Cincinnati packets.

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Big Coal River, in Kanawha and Boone Counties, is improved by locks and dams by the Coal River Navigation Company to the Peytona Mines, 35 miles above its mouth. Many years ago Little Coal River, a branch of Big Coal, was locked and dammed for the first few miles for the accommodation of the Marac Mining Company, but the works have now gone to ruin, owing to the suspension of the mines. This stream could be improved as high as Boone Court-House, which is some 40 miles from the Kanawha.

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Greenbrier River.—The Saint Lawrence Boom and Manufacturing Company, whose boom and saw-mills are at Ronceverte, Greenbrier County, have a charter to improve the navigation of this stream. The work so far done has been to remove the obstructions to the lumber business, so that logs can come down freely.

New River.—The Greenbrier, New, and Kanawha Rivers is the intended route of the James River and Kanawha Canal from Richmond, Va., to the Ohio River. The gap still left for completion between this last point and Buchanan, on the James River, in Virginia, is 207 miles.

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Gauley River.—In 1872 a charter was granted the Gauley River Improvement, Manufacturing, Mining, and Lumber Company, giving it the exclusive privilege of improving the river by removing obstructions to the navigation, and by constructing dams, by cutting a canal, or by sluices. So far, the only work done has been to improve the navigation so that logs can come down freely from Peter's Creek, which is some 20 miles above the Kanawha.

Elk River.—The Elk River Navigation Company have put in one dam above Charleston, and the stream has been so improved that on a good stage of water a small steamboat can go up 70 miles to the furnace of the Elk River Iron and Coal Company. In this distance, according to the survey of the Northern and Southern West Virginia Railroad, the fall of the river is 206 feet.

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FAYETTE COUNTY.

The surface of Fayette is hilly, mountainous, and high table-land. The hills and mountains usually are not precipitous, and have a fertile soil. The soil is a rich light loam and a sandy loam, which is well suited for the culture of tobacco.

There are some fine bottom-lands. On Meadow River the soil is 6 inches deep on the hills and 12 inches or more on the levels.

The grains and crops especially suited to the lands are corn, oats, wheat, rye, tobacco, and grass.

The principal exports are coal, timber, tobacco, and stock.

Principal industries are coal-mining, farming, lumbering, and stock-raising.

Markets: The tobacco goes to Richmond, stock to Baltimore, timber to New York and Cincinnati.

Minerals: Coal in large amounts, in fine, workable seams—soft, bituminous, splint, and cannel; the two former are those mined and shipped. Some limestone, but poor; fine sandstone for building purposes. The mineral-waters are alum and chalybeate. Several important coal mines are in operation in this county: the Gauley Kanawha Coal Company, (limited;) Longdale Coal and Iron Company; New River Car Company; Nuttallburg mines; Coal Valley Coal Company, and a new mine now being opened by George Straughan. Besides these there are several mills and factories, among which we may mention the Fayetteville Tobacco Factory, making 2,568 pounds yearly; Junction Saw-Mill Company; Atlantic Barrel Company; Koontsman & Co.'s shook and stave factory; Kanawha Falls Lumber Company.

The principal streams are the Gauley, New, and Kanawha Rivers. The Kanawha is

navigable six months for steamboats and twelve months for batteaux; Gauley, eight months for batteaux and twelve months for canoes for 12 miles; New River in the lower part is too rough for canoes even; in the upper part it is navigable for batteaux.

The lines of transportation are the rivers and the Chesapeake and Ohio Railroad, and the James River and Kanawha turnpike.

Contemplated improvements: Locking and damming Kanawha and New Rivers, and the continuation of the James River and Kanawha Canal from its present eastern terminus.

Public schools, 63; post-offices, 23; churches, 10; population, 6,647. Value of taxable property, $1,440,839.83. County-seat, Fayetteville; newspapers, Fayetteville Enterprise, weekly.

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GREENBRIER COUNTY.

This county on the eastern and western sides is mountainous, the western mountains rising high above the sea, but not so much in proportion above their bases.

They are not too rugged for cultivation in parts, or for grazing.

The central portion is a rolling plateau, embracing very fertile and highly cultivated grass and grain lands. The soil on the eastern and western sides is a red clay or clay loam. In the central portion, over the limestone, the soil is yellowish-red, clayey and calcareous loams. The depths on the hills are 4 to 6 inches; on the levels, 12 to 18 inches. The crops best adapted to the land are corn, wheat, oats, buckwheat, grass. Corn produces on the levels 20 to 40 bushels; wheat, 15 bushels; oats, 30; buckwheat, 30; potatoes, 100. On the hills corn produces 10 to 15 bushels; oats, 15; wheat, 8; buckwheat, 35; potatoes, 75. No manure used for these yields. The value of the land is: Best agricultural, $20 to $50; second-class and rougher land, with less improvements, but some subsoil, $2 to $10; timber-lands, $1.50 to $6; iron and coal lands are worth from $2.50 up to $100, according to distance from railroad and richness of deposit. In the northern part, near the Greenbrier River, is a good deal of valuable timber, especially white pine. Timber is worth, stumpage, $1.25 per 1,000 feet; at the mills, $6 to $7.50. The principal industries are farming and stock-raising. The principal exports are grass-fed cattle, sheep, horses, wool, &c. The country is emphatically a grazing one.

The market for stock is Baltimore; some goes to Richmond. Surplus grain is fed to shipping-stock. Horses go to North Carolina and East Virginia. For timber, Baltimore and other eastern cities.

In the western part some workable seams of coal; fine workable iron-ores on Anthony's and Howard's Creeks and elsewhere. Limestone in abundance of all qualities, for agricultural, building, and hydraulic lime; clays, suitable for rough crocks, are found, and these were made for years at Lewisburg. Excellent grit for grindstones is found.

Mineral springs: White Sulphur, Blue Sulphur, and Alum. Many chalybeate springs. Coal was formerly worked on Little Sewell, and hauled 22 miles to Lewisburg; now discontinued on account of more ready transport on the Chesapeake and Ohio Railroad for the coals further west. Manufactories: 4 carding-mills, 3 woolen mills, 1 tan-yard exporting leather, and several smaller ones; Saint Lawrence Boom and Manufacturing Company. The Greenbrier River is the principal stream, and is navigable for canoes and batteaux on rises. Means of transportation, Chesapeake and Ohio Railroad, and turnpikes.

Contemplated lines: The Pittsburgh, Virginia and Charleston Railroad.

Schools: Lewisburg Female Institute, high school at Frankford, and 68 public schools. Post-offices, 22; churches, 35; population, 11,417. Taxable property, $4,524,562.59. County seat, Lewisburg; newspaper, Greenbrier Independent, weekly.

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KANAWHA COUNTY.

The topography of this county is hilly and mountainous. The hills in the west are comparatively low; in the middle portion they become quite high, and in the western part they become mountainous. Much of the surface is quite rough and broken. The valleys are usually narrow. The soil is naturally productive, and is quite deep. On the hills it varies from 4 to 12 inches, and on the levels from 12 inches to many feet. The crops suited to the lands are corn, wheat, oats, rye, and tobacco. On the bottoms, as those along the Kanawha, the yields are high. Corn produces 40 to 60 bushels; oats, 30 to 40 bushels; wheat, 10 to 15 bushels; tobacco, 1,000 to 1,400 pounds. On the hills corn produces 20 to 50 bushels; oats, 20 to 25 bushels; wheat, 8 to 10 bushels; tobacco, 800 to 1,000 pounds. Value of improved lands, $5 to $50; of mineral-lands, coal, $10 to $100, according to location and deposits; timber-lands, $5 to $20. Value of timber, stumpage, 2 to 3 cents; at mill, 8 to 10 cents per cubic foot.

Principal industries: Farming, lumbering, coal-mining, and the manufacture of salt. Principal exports, coal, salt, timber, grain, and tobacco. Markets for timber, Ohio River and eastern cities; for grain and farm-produce, Charleston and home. Stock goes east, as does some of the timber. The coal goes down the Ohio and to the eastern cities.

The principal minerals are coal, iron, and salt. The iron is siderite and black-band. The former has been worked somewhat. Large exports of salt are made, mainly down the Ohio and to Richmond. Fire-clay was worked and shipped to Cincinnati. Sandstone for building can be obtained of good quality. There are: 1 tobacco manufactory, manufacturing 648 pounds; 3 cigar-manufactories, making 51,100 cigars; 1 brewery, making 722 barrels; 1 bromine-works.

Mines: These are exclusively of coal, which is common bituminous, splint, and cannel. The mines now in operation are Bibby's mine, Pioneer Coal Company, Campbell's Creek Coal Company, J. B. Lewis & Co., Coalmont Coal Company, Houston Mining and Manufacturing Company, Kanawha and Ohio Coal Company, Hampton Mines, Blacksburg Mines, Blackberry Mines, Enterprise Coal and Iron Company, Kanawha Semi-Cannel Coal Company, Gordon and Seal Cannelton Coal Company, and various mines to supply the salt company. Salt companies are Brooks Furnace, Lorena Furnace, Snow Hill Furnace, Campbell's Creek Furnace, Pioneer Furnace, a furnace a short distance above Malden; now building at Charleston, the Kanawha Coal and Iron Furnace. Lines of transportation now used: Kanawha River, navigable by steamboats and barges; Elk, navigable for batteaux in all stages, and for rafts in full water, and also for small steamers, 10 miles. Big Coal is locked and dammed to Peytona, and used by small steamers and barges. Rafts are sent out of Pocatalico in full stages.

Contemplated improvements: The locking and damming of Elk, extension of the James River and Kanawha Canal, Coal River Railroad, Northern and Southern West Virginia Central Railroad, Paint Creek Railroad, West Virginia Railroad, the West Virginia Central Railroad. Public schools, 125; churches, 37; post-offices, 24; population, 22,349. Value of taxable property, $6,430,051. County-seat, Charleston, with a population of 5,000. It has 1 woolen-mill, 2 barrel-factories, 10 steam saw-mills, in and near Charleston, 1 brewery, 1 foundery, 2 tanneries. One steam saw-mill is at Saint Albans, and another at Coalburg. Newspapers: Charleston Courier, tri-weekly; Kanawha Chronicle, weekly; West Virginia Journal, weekly; all at Charleston.

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MASON COUNTY.

The surface of this county is gently rolling and hilly, with much flat land along the Ohio and Great Kanawha. The hills are low and gently sloping, comparatively speaking, and the valleys are wide. The Ohio skirts the county for 50 miles, and the Kanawha passes through its center. The county has 75,000 acres of river-bottom. The soil on the flats is a rich loam, very deep. Clay loams, clays, and calcareous loams are found on the hills. More than half of the land is in cultivation, and the rest contains a great deal of fine heavy timber. The levels have a soil from one to many feet deep, while on the hills it is from 8 to 12 inches. The crops raised are corn, wheat, oats, rye, and the grasses, which do finely. The yields on the bottoms are wheat, 15 to 20 bushels; corn, 40 to 50; oats, 30 to 40; rye, 30. On the uplands, corn yields about 30 to 35 bushels; wheat, 10; oats, 25 to 30, &c. No manures used for these yields. Corn has been produced on the flats at the rate of 106 bushels in a 30-acre field. The Mason County Agricultural and Mechanical Association holds an annual fair at Point Pleasant. Value of premiums distributed, $1,000.

The bottom-lands sell for $80 to $100 per acre, the uplands for from $5 to $20; mineral-land, (coal,) $200 to $400; timber, stumpage, is worth $1 per tree; at the mill, $10. The principal industries are farming, stock-raising, lumbering, salt-manufacturing, mining, &c. Mason pays a good deal of attention to stock and the introduction of improved breeds, for the raising of which its fine grass-lands afford many advantages. The principal exports are: Coal, 5,000,000 bushels; salt, 2,500,000 bushels; wheat, cattle, bromine, nails, glass, wool, hogs, lumber, &c. Markets: The agricultural products and stock go to eastern cities; others down the river.

Minerals: Coal, in a seam from 5 to 6 feet, is exposed above water-level for 7 miles, in the northern edge of the county. Salt-water is furnished from wells 1,000 to 1,200 feet deep, in the northern part of the county. Clay, for tile-making, is found and worked. Sandstone of good quality abounds in the county. Mines: Coal is mined at nine different openings from Camden to New Haven City. They send 5,000,000 bushels down the Ohio, and use half that amount in making salt. This is soft bituminous coal. Manufactories: Mason County has one brewery making 126 barrels of beer per annum.

Salt is manufactured by 11 companies, with 13 furnaces. These, with the coal-mines and other manufactories, make a continuous village along the Ohio for 6 miles. There are bromine-works at Clifton, Mason City, and Valley City, and two at Hart-

ford City. One nail-factory and rolling-mill of large size at Clifton, 2 glass-factories at Mason City, 2 stove-factories at Hartford City; also, 2 steam saw-mills at Mason City, 1 steam saw-mill and 1 keg-factory at Clifton, 1 tile-factory opposite Point Pleasant, 1 flour, 1 lumber and planing-mill, at Point Pleasant, 1 flour-mill at New Haven City, 3 saw-mills along the Ohio above Point Pleasant, and 1 floating-dock at that point. Principal streams: The Ohio and Kanawha, both navigable for large steamers.

Present means of transportation: The Ohio and Kanawha Rivers. Improvements contemplated: The improvement of the navigation of the Kanawha; the Washington and Ohio Railroad; the W. C. and Saint Louis Narrow-Gauge Railroad; the Pittsburg, Wheeling and Kentucky Railroad; Hartford, Mason and Clifton Railroad.

Public schools, 96; churches, 29; post offices, 22; population, 15,978. Value of taxable property, $6,207,710.49. County-seat, Point Pleasant. Newspapers: The Weekly Register, The Mason County Journal, both weekly.

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MONROE COUNTY.

What was said of the topography, soil, products, &c., of Greenbrier, applies in great part to Monroe. The surface is hilly and undulating, rising suddenly at some points into pretty high mountains. The soil is loam, clay and calcareous clayey loam, producing fine farming and grazing lands. Depth on hills, 4 to 10 inches; on levels, 12 to 18 inches. Crops are: Corn, oats, wheat, grass, and tobacco. Corn yields, on the level lands, 30 to 40 bushels; wheat, 15; oats, 25 to 30. On the hills: Corn, 10 to 15; wheat, 8 to 10; oats, 15. Value of the land, which is mainly agricultural, $10 to $50; timber-land, $5 to $20. Value of the timber: Stumpage, 50 cents per tree; at the mill, $8 to $15. Principal industries: Farming and grazing. Principal exports: Stock of all kinds, and farm produce, tobacco, &c. Markets for grain and tobacco, Richmond; for stock, Baltimore. Minerals: Iron in workable quantities, (brown hematite;) limestone in abundance, for building and agricultural purposes. Several celebrated mineral springs exist in this county, viz: "The Red Sweet," "Salt Sulphur," &c. The manufactories are not reported. One cigar-factory is worked, making 3,000 cigars. Principal streams, New and Greenbrier rivers. Present means of transportation: Chesapeake and Ohio Railroad, and turnpike roads. Contemplated: The New River Railroad, the improvement of New River, and the extension of the James River and Kanawha Canal. Schools: 1 high school, 1 female seminary, and 69 public schools; churches, 32; post-offices, 15; population, 11,123. Value of taxable property, $2,891,953.20. County-seat, Union. Newspapers: Border Watchman and Monroe Register, both weekly.

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NICHOLAS COUNTY.

The surface is hilly, moutainous, and plateau or glade. The soil is generally good. Much of it is held in large tracts, and is unimproved or in original forest. The soil is loam, sandy, and sandy loam; depth on hills, 4 to 8 inches; on the bottoms, 8 to 20 inches. Crops raised are: corn, oats, wheat, rye, Irish and sweet potatoes; corn being on the levels 30 to 40 bushels; wheat, 10 to 12 bushels; rye, 15 to 20 bushels; potatoes, 100 to 150. On the hills: Corn, 15 to 25 bushels; wheat, 8 to 10 bushels; rye, 10 to 15 bushels; potatoes, 50 to 75 bushels. The unimproved land is worth from $1 to $3 per acre, and the improved $5 to $15. Timber is worth, stumpage, about $1 per tree; at the mills, $7.50 to $12. Principal exports: the products of farming, grazing, and lumbering. For want of means of transportation but little is sent out of the county, and this is mainly timber and stock. Market for stock, Baltimore; for timber, mouth of Gauley, where it is sawed up. Minerals: Coal, bituminous, (ordinary,) splint, and cannel, in workable seams above water-level. Good sandstone for building; also millstone and grindstone grits. Brine has been found in the county. Principal stream: Gauley, navigable for rafts and single logs on full tides. Present means of transportation: County roads. Contemplated: Improvement of the navigation of the Gauley, Gauley River Railroad. Public schools, 49; churches, 11; post-offices, 8. Population, 4,458. Value of taxable property, $990,847. County-seat, Summerville.

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PUTNAM COUNTY.

This county is generally hilly and rolling. It has a good deal of bottom land of considerable fertility on the Kanawha and the numerous creeks. These bottoms are a mile wide on the Kanawha, and have a deep loam. On the hills the soil is clay and calcareous clayey loam, of considerable productiveness. The county is wooded over five-sixths of its area. The crops are corn, wheat, oats, buckwheat, and tobacco. Yields of corn on the bottoms are 50 to 80 bushels; wheat, 12 to 15 bushels; oats, 25 to 30 bushels; while on the hills corn produces 20 to 30 bushels; wheat, 8 to 10. The

soil on the bottoms is many feet deep, and on the hills 12 to 18 inches, producing fine grass and tobacco. Value of land: Kanawha bottoms bring $100; other lands from $1 to $20, according to location and condition. Timber, stumpage, is worth about $1 per tree; at the mills, $13. Principal industries: Farming and lumbering. Principal exports: Lumber, cooperage stuff, grain, and coal. Staves, &c., go to England; farm produce to Richmond and Cincinnati; Timber, in logs, and coal are sent down the river to Cincinnati, &c. Minerals: Coal of fine quality and workable in quantity is above water-level. Some good limestone and sandstone suitable for building occurs. Mines: Raymond Coal Company, shipping annually from 1,300,000 to 1,400,000 bushels; Oak Ridge Colliery has just commenced operations. Manufactories, &c.: A large flour-mill at Buffalo; flour and saw mill at Winfield; saw-mill at Hurricane and at Raymond City, all driven by steam. Principal streams: Kanawha, navigable for steamers; Pocatalico, navigable for batteaus and rafts in good water. Present means of transportation: Kanawha River and Chesapeake and Ohio Railroad. Contemplated: Improvement of the Kanawha River, now going on, and the West Virginia Railroad. Public schools, 48; churches, 14; post-offices, 11; population, 7,794. Value of taxable property, $1,823,624. County-seat, Winfield. Newspaper, Winfield Independent, weekly.

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RALEIGH COUNTY.

The surface of Raleigh is hilly and mountainous, with a large proportion of plateau-land, covered with undulating and rolling hills. The rivers cut deeply into the plane of the country, and the roughest land lies in the sides of the hills facing them. The soil is loam or sandy loam, 4 to 6 inches deep on the hills, and 6 to 10 inches, or more, on the levels. The hills and levels produce about alike. The crops are corn, wheat, oats, buckwheat, and potatoes. Yields are: Corn, 20 to 40 bushels; oats, 20 to 25; wheat, 10; rye, 15 to 25; potatoes, 100 to 150. Price of agricultural land, $5 to $15; of timber and coal lands from $1 to $5. Timber is worth 50 cents to $1 per tree, according to kind and location; at the mills, $10 per 1,000. Principal industries, farming and stock-raising. Principal exports, cattle. Market-cattle go to Baltimore. Manufactories, &c., several steam saw-mills, besides the usual grist and saw mills on streams. Minerals: Coal, in workable seams, of good quality; iron, in workable quantities; sandstone, of good quality for building; good millstone grit. Principal streams: New River, navigable for batteaus; Piney River, for logs in full water. Present means of transportation: Chesapeake and Ohio Railroad and county roads. Contemplated: the improvement of New River and the Coal River Railroad. Public schools, 47; churches, 4; post-offices, 10; population, 3,673. Value of taxable property, $730,862.19. County-seat, Raleigh Court-House.

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F 7.

IMPROVEMENT OF NEW RIVER, FROM THE LEAD-MINES, IN WYTHE COUNTY, VIRGINIA, TO THE MOUTH OF GREENBRIER RIVER, WEST VIRGINIA.

A survey of this portion of the New River was made in 1872, and a report submitted January 9, 1873, which may be found in print in the Annual Report of the Chief of Engineers for 1873, beginning at page 852. Two estimates were therein made for the improvement of the river.

The first looked to facilitating the navigation by the keel-boats now used, at a cost of $100,000. This was to be accomplished by constructing slight deflectors or dams of rock and brush, in order to concentrate the volume of the water and increase the depth over the shoals from the present average of about 12 inches to about 2 feet, which could be done without too much increase of velocity. And some of the falls, which are almost always vertical and of an average height of about 4 feet, could be greatly improved by blasting sluices through them about 30 feet in width and of an average length of 50 feet. In many cases the falls have already natural chutes or sluices through them susceptible of a similar improvement.

But there is a strong demand for the introduction of steamboats on the river. Hence the second estimate, which was for a 3-feet steamboat navigation, to cost $1,000,000. It was supposed that light-draught steamboats could, for short distances, ascend a grade of 1 in 400, with a current of 5 miles an hour. It was therefore proposed to excavate sluice-ways 90 feet wide and 3 feet deep through all shoals having a grade not exceeeing 1 in 400. Where the grade exceeds this, low regulating dams were proposed, with sluices having a fall not exceeding 1 foot at each. In several cases dams were to be introduced containing locks, and in two other places lateral canals.

The first appropriation made for this improvement was $15,000, August 14, 1876, but authority for its expenditure was not given until in May, 1877. As this appropriation was insufficient for a general improvement, it seemed necessary to confine what should be done at present to a limited portion of the river and to that scheme which involved the least expense, viz, for the keel-boats now in use; it being the understanding that what is first done in the smaller improvement should be arranged with a view to its utilization and adaptation some future day, when the means provided shall suffice to enter upon the improvement of the river for light steamboats.

It seemed also expedient that the first portions of the river treated should be in the vicinity of New River Bridge, in order to facilitate communication of at least a portion of the country through which the river flows with an existing outlet east and west, the Virginia and Tennessee Railroad, which is itself in connection with the whole system of rail and water intercommunication of the country.

Captain J. W. Cuyler, Corps of Engineers, has been assigned to the immediate supervision of this work, which is expected to be completed, as far as the available funds will allow, before the close of 1877.

Money statement.

Amount appropriated by act approved August 14, 1876	$15,000 00
July 1, 1877, amount expended during fiscal year	78 25
July 1, 1877, amount available	14,921 75
Amount (estimated) required for completion of existing project	85,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	50,000 00

F 8.

IMPROVEMENT OF THE CAPE FEAR RIVER, NORTH CAROLINA.

At the close of the fiscal year ending June 30, 1876, all work on the river was suspended, except the making of some hydrographic examinations of small extent and a few tidal observations.

An appropriation of $132,500 was made by the act of August 14, 1876, of which $110,000 became available about the middle of September. Proposals for stone with which to continue the construction of the closing work between Zeke's Island and Federal Point were at once called for, and received October 16. Fourteen were received, but they were all too high and were rejected. A new advertisement was issued, under which bids were received November 8. A contract for the delivery of about 45,000 cubic yards of stone was awarded to Bangs & Dolby, to be delivered by end of 1877. They commenced delivering in January,

and up to July 1, 1877, have supplied 20,304 yards. The stone comes from the Magnolia quarry on the northwest branch of the river, about 14 miles from Wilmington. It has been chiefly placed on the sections of the apron next to Zeke's Point and Federal Point. The closing work is as high as low-water for about two-fifths of its length between these two points, but the full width has not yet been given to it.

The name of Zeke's Island has come to be a misnomer, as there is now a continuous bank of sand, making but one island of the two so long called Smith's and Zeke's Islands. At Federal Point, during the year, there has also been a general accretion, and an extension of the shore-lines into the sea, and the general surface has risen.

Two destructive storms have occurred during the year, both combined with very high tides. The first was in the middle of September, 1876, and the other in the middle of April, 1877. No damage of importance was done by either, and in some respects their effect was beneficial. The storm of April is believed to have been the most severe experienced on the Cape Fear River for more than forty years.

No great changes have occurred during the year in the shore-lines of Baldhead Point and the opposite point of Oak Island.

The depth in the Baldhead Channel has fallen off a little since the suction-dredge ceased operating there. The least soundings are 10½ feet at mean low-water, but generally 12 feet and over, excepting for short distances over soft sand. On the inner bar of the Oak Island Channel the depth has lately increased somewhat, and is now about 8½ feet at mean low-water. The new cut behind the Horseshoe Shoal has shoaled near the upper end, opposite New Inlet. The complete closure of New Inlet will probably be needed for the permanence of this cut. The new-dredged channel at the "Logs" has answered its purpose well, but its width, 130 feet, is not sufficient. It should be increased to 250 feet, and the revised estimate provides therefor.

The indications still lead one to expect a favorable conclusion at no distant day to this interesting and important work, if sufficient funds be provided for its proper progress.

Extensive surveys have been made during the year by Mr. Bacon. The suction-dredge has been laid up since early in 1876 for want of funds. She needs extensive repairs and improvements, (recent inventions,) but her working in the Baldhead Channel is quite important, and her thorough refitting is therefore included in the revised estimate.

Mr. Henry Nutt, chairman of the committee of the Chamber of Commerce of Wilmington on the improvement of the Cape Fear River, has continued, as heretofore, to exhibit a laudable and marked interest in the work, and has furnished much valuable statistical information relative to the commerce on the river, all of which is appended hereto.

Mr. Henry Bacon has continued in the immediate supervision of this important improvement in his usual faithful and efficient manner.

Money statement.

July 1, 1876, amount available	$22,722 72	
Amount appropriated by act approved August 14, 1876	132,500 00	
		$155,222 72
July 1, 1877, amount expended during fiscal year	63,434 12	
July 1, 1877, outstanding liabilities	3,856 35	
		67,290 47
July 1, 1877, amount available		87,932 25
Amount (estimated) required for completion of existing project		160,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		160,000 00

Proposals for furnishing and delivering stone for contracting the New Inlet, Cape Fear River, North Carolina, opened at 12.5 o'clock p. m. October 18, 1876.

Number.	Name and residence.	Northern stone.		River stone.			Quantity furnished monthly, cubic yards.	At what intervals cargoes may be expected.	In what quantities cargoes may be expected.	Weight per cubic foot.	Price per linear foot for addition to base of apron.	Time.	
		Price per cubic yard.	Price for heavier stone and in larger pieces.	Price per cubic yard delivered on lighters.	Price per cubic yard delivered upon apron.	Place where lighters will be loaded.						Commence—	Complete—
1	H. Johnson, Wilmington, N. C			$1 57½ 1 60		Northeast Branch Cape Fear. 12 miles above Wilmington.	2,500					10 days after receiving contract.	
2	Bangs & Dolby, Manlius, N. Y		On apron, $3 40.		$2 35		3,000				*$18 28		
3	Ballou & Sylvester, Boston, Mass	$3 88 per ton on apron.	$9 23 per yard.		8 73					166⅔		November 18, 1876.	Aug. 18, 1877
4	Old Dominion Granite Company, Philadelphia, Pa.	$4 90										30 days from date of contract.	May 31, 1877
5	E. C. Sargent, Quincy, Mass	3 50					1,500		200 to 600	160		10 days from award of contract.	
6	J. Wescott & Son, Portland, Me	6 85					1,000			170		10 days after signing contract.	
7	J. S. Hopkins, Vinalhaven, Me	4 90					500	4 per mo	125			November 1, 1876	June 30, 1877
8	French & Ross, Wilmington, N. C.				2 39	Northeast Cape Fear River.	3,000					November 1, 1876	Nov. 1, 1877
9	Fowler & Gilbert, Georgetown, D. C.	3 75	$4 25 5 50				2,000					When bid is accepted.	
10	Davis Tillson Rockland, Me	2 49										November 18, 1876.	Dec. 31, 1877
11	W. H. Beard, Brooklyn, N. Y	3 73	5 47 4 23				2,200				†19 00	When bid is accepted.	
12	G. Z. French, Wilmington, N. C			1 40		31 miles above Wilmington.	3,000					November 1, 1876	Nov. 1, 1877
13	Ingerson & Molthrop, New London, Conn.	On apron, $4 25.			2 34					130	12 50	November 20, 1876.	Oct. 1, 1877
14	R. G. Ross, Wilmington, N. C										13 44	November 1, 1876	

* Will close New Inlet for $130,000, (guaranteed.)

† Will deliver on apron for $1.50 and $1 extra.

Price too high; all rejected.

Cape Fear River, North Carolina; proposals for furnishing and delivering stone; bids opened at 12.5 p. m. November 8, 1876.

Number.	Name and residence.	Number of cubic yards furnished monthly.	Price per cubic yard.	Time.		Remarks.
				Commence—	Complete—	
1	Alfred Sampson, Quincy, Mass	4,000	$5 25	Dec. 8, 1876	Dec. 8, 1877	
2	F. H. Smith, New York, N. Y	4,000	3 97	Dec. 1, 1876	Dec. 1, 1877	
3	Fowler & Gilbert, Georgetown, D. C	4,000	4 24	Dec. 1, 1876	Dec. 1, 1877	
4	Bangs & Dolby, New York, N. Y..	4,000	1 89	Dec. 1, 1876	Dec. 1, 1877	Contract awarded.
5	French & Ross, Wilmington, N. C..	4,000	1 97	Nov. 20, 1876	Nov. 20, 1877	

REPORT OF MR. HENRY BACON, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Smithville, N. C., June 10, 1877.

MAJOR: I have the honor to submit the following report of operations for the improvement of Cape Fear River, North Carolina, during the eleven months ending May 31, 1877.

The work done has been mostly confined to stone-filling on the timber, brush, and stone foundation which was placed entirely across the New Inlet, from Federal Point jetty to Zeke's Island, during the previous fiscal year, and fully described in the last annual report, the object of the work being the speedy closure of the New Inlet, which is considered the most important step in the improvement of the river.

All operations, excepting for slight repairs of the old works, and surveys, examinations, and tidal observations, were suspended during the first six months, on account of the approximate exhaustion of the former appropriation and the non-availability of the appropriation of 1876, and delays incident to advertising and awarding the work.

After twice advertising, the work was finally awarded to Messrs. Bangs & Dolby, at $1.89 per cubic yard for riprap stone delivered and placed on the apron-foundation to the required height, width, and slopes. The contract was executed December 16, 1876, and the work began in January, 1877.

The following are the amounts of stone delivered during the several months:

	Cubic yards.
January, 1877	763
February, 1877	2,147
March, 1877	3,561
April, 1877	3,226
May, 1877	6,059
Total	15,756

The hinderances incident to the season of the year, and opening and developing the quarry, prevented the delivery of stone as fast as the contract required. These are now overcome, and there is a good prospect for the delivery of the full amount within the time required.

The stones have all been taken from the Magnolia quarry, about 14 miles above Wilmington, on the northwest branch of the river. It is a peculiar species of limestone, mostly blue, weighing about 144 pounds per cubic foot. It comes from the quarry in excellent shapes to form a compact and coherent mass.

The stones have been placed mostly on the sections of the apron next to Zeke's Island and Federal Point and on the old crib-jetty foundation which forms a part of the closing work, the superstructure of which had been worm-eaten and washed out.

At Zeke's Island the sand beach has closed over about 400 feet length of the apron, and the stone filling is made nearly to mean low-water for a farther distance of about 500 feet. The whole of the section next to Federal Point, 920 feet in length, with 400 feet length over the old jetty, making 1,320 feet, is nearly filled to mean-low water, and on all but the southerly 300 feet there is a ridge of stone from 2 to 4 feet above low-water, but the quantity is not equivalent to 16 feet width with the required slopes, and will require additions.

The whole length of the apron was 4,352 feet, and with the jetty as above the length from shore to shore was 4,752.

It was expected that the foundation-mattresses would require widening in places, and that perpendicular jetties might also be required to arrest the disposition to scour

by currents parallel to the apron. Preparations for the work have been made. Timber for about 300 feet length and 40 feet width has been purchased, and the appliances for placing the mattresses made ready. The necessity for this work is not yet apparent. The further purchase of materials has been suspended.

In the vicinity of the New Inlet, at the center and westerly side of the main channel, as well as along Snow's marsh, the tidal currents are up and down with those of the natural entrance at all stages of the tide, while on the eastern side of the main channel adjacent to the inlet the currents are directly affected by the inlet. The first flood of the inlet joins the main ebb-tide at Zeke's Island, and flows with it till met by the main flood. At the same time the inlet flood presses latterly and upward into the main ebb in well-defined lines till the main flood forces it back again, so that finally, at the last of the inlet flood, the main flood crosses the line of the apron at the section next to Zeke's Island, and runs parallel to the middle section, and recrosses the section next to Federal Point. These currents soon change with the ebb-tide of the inlet, which draws with it a considerable amount of the main flood, till the main current turns down. The main current is up for an hour or more, after the beginning of the inlet ebb, and is down for an equal time after the inlet flood begins. The time of low-water at Snow's marsh (opposite New Inlet) is apt to be about half an hour behind that at Federal Point, while that of high-water is nearly simultaneous.

These tidal movements, while exhibiting the overwhelming volume of entrance tides, and comparative insignificance of those of the New Inlet, demonstrate the great disturbing forces of the inlet and point to the conclusion that at the final closure of the inlet, the range of the tides will be increased in the great tidal reservoir, and this, with the large amount of water now flowing in and out at New Inlet, will be added to the scouring power at the mouth.

In short, the general effect of the New Inlet is to retard the main flood, and afterward draw off a portion of it, and in a similar manner to retard the main ebb and add to its volume at the time of its meeting the main flood, thus preventing the filling and emptying of the great tidal reservoir, and reducing the power of the currents at the mouth.

By reference to the table of tidal observations and results annexed hereto, it will be seen that the comparative *range* of the tide is about 16 per cent. greater at Smithville than at Federal Point, while it is only about 6 per cent. greater at Federal Point than at Campbell's Island. The distances are about 5 miles from Smithville to Federal Point and 12 miles from Federal Point to the place of observation at Campbell's Island.

The effect of the work done during the present season is perceptible. The inlet flood does not force itself so far into the river, and the influence of the ebb-tide is also perceptibly less. There is good reason to attribute the late increase of depth which has occurred at the "Rip" of the western entrance channel to this work. This increases the importance of assisting the natural forces in opening the Bald Head Channel, a subject to which I will hereafter recur.

A series of tidal observations will be made during the present month at several points in the river, and especially at Smithville, Federal Point, and Campbell's Island, to exhibit by comparison with similar observations of 1876 the variations caused by the work done.

At Federal Point, during the year, there has been a general accretion and an extension of the shore-lines into the sea. At the old jetty and some other places there has been some abrasion. The general surface has risen. The abrasion at the jetty was probably occasioned by the washing away of the old superstructure, which has occurred during the year.

Considerable changes have occurred at Zeke's Island. The beach, which at the end of the year had closed over 175 feet length of the apron, has since closed over a farther distance of about 225 feet. There has been alternate accretion and abrasion, especially near the junction of the old works with Smith's Island. A shoal on the easterly side of the island has gradually risen, and at the same time moved westward toward the island, till it is now an island small in extent, above ordinary high-water.

Two destructive storms have occurred during the year, both combined with very high tides. The first was September 17, 1876, and the other April 13, 1877. The first storm carried away two sections of the old superstructure, each about 150 feet in length; one about 900 feet from the end of the apron, and the other at the more exposed place, about 600 feet from the end of the works, at Smith's Island. The timber was completely worm-eaten below mean tide, so that but little force beyond the buoyancy of the water was needed to move it. All the stone were left, and still remain intact, at the first-named place. At the other place, near Smith's Island, where the gap was exposed to the sea, some of the small stones were washed out by the first storm, and the water flowed back and forth at a little above half-tide. This was repaired by placing a small quantity of stone in the gap, over which sand and beach soon closed, after a large amount of sand had been washed through the breach from the sea-side, thus leaving the old works stronger than before.

At the great storm of April 13, 1877, when the very high tide which covered every part of Zeke's Island, including all the superstructure and only excepting a few grassy sand-hills at the head, was combined with a terrific northeast gale, the passage through the breach was again made, and more of the small stones washed out, leaving the foundation, which was composed of large stones, secure. This has since been repaired by placing more stone in the breach, and the beach has again closed over it. During the same storm, about 250 feet length of the old worm-eaten superstructure near the other breach was tilted up but not carried away, as it was not exposed to the sea. The storm and waves swept furiously across the island, and cut down its general crest-level from 1 to 2 feet, carrying the sand into the hollows and over the works to the river-side. This storm, which is believed to be the severest that has occurred at Cape Fear River for more than forty years, left Zeke's Island in better condition than before.

Its effect on the long sand-spit of Smith's Island was remarkable. This beach, for several miles southward from the head, has been lined with a wall of sand-hills since the memory of the oldest inhabitants of Smithville. These were nearly all swept clean by the storm, and spread over the adjacent marshes and flats to a width of from 200 to 500 feet, and graded as nicely as if artificially done. A few sand-hills are left at the head of the island, and a few farther south, which are well back on the marsh. Near the place of the former "swashes," about 3 miles from the head of the island, the sand is washed away, leaving the marsh, which is the foundation of the whole beach, nearly bare, and the water passes across at less than half-tide, but not at low-water. For some time after the storm the spring-tides washed across nearly 2 miles of this beach. Ever since the storm, the natural forces of wind and waves have tended to strengthen the beach and close the "swashes." The crest of the beach has risen from 1 to 2 feet for several miles, and it is probable that the sand-hills will again rise. There is a slower tendency to closing the swashes. There seems to be no danger of a permanent inlet, as the water is very shoal in the bay, and has been made more so by the storm. A good field is now presented for planting and propagating beach-grass on ground thus leveled and graded along this island. Experiences in other similar localities seem to demonstrate its probable efficiency here in preserving this beach.

No great changes have occurred during the year in the shore-lines of Bald Head Point and the opposite point of Oak Island.

These appear to be rather favorable than otherwise to the development and preservation of Bald Head Channel, as the present condition of the point interferes less with the general direction and force of the main channel, and thus diminishes the tendency to force the main current over the "Rip" into the western channel.

There has been very little change in the Bald Head Channel during the year either in position or depth. The shortest soundings are 10½ feet at mean low-water, and generally 12 feet and over, excepting for short distances, over soft sand. At the "Rip" of the western channel the depth has lately increased to 8½ feet at mean low-water.

The new cut behind the Horseshoe Shoal has retained the depth originally dredged, excepting for about one-third of a mile length at the upper end, where a constant tendency to shoal has been noted, caused by the tidal currents crossing it obliquely, particularly of the ebb-tide. The original depth of 12 feet at mean low-water is reduced to 8½ feet at some places, and there is a general shoaling on all this portion of the cut. This tendency will be cured to some extent by the closing of New Inlet. An estimate for dredging and widening the upper end of the channel is appended.

The new dredged channel at the "Logs," near Campbell's Island, retains the original depth. It is only 130 feet in width, and should be widened to make it more serviceable.

An estimate for widening it to 250 feet is appended.

I have made an exhaustive hydrographic survey of the channel and vicinity. The map has been completed under my direction and forwarded to you.

A like survey of the river between New Inlet, Snow's marsh, and the deep water above Federal Point, and below Price's Creek light-house, is nearly completed. In both surveys the soundings were all made with a pole and trigonometrically located.

Surveys and examinations have been made from time to time at the New Inlet, over the apron and on each side of the same also of Federal Point, Zeke's Island, Smith's Island, and Bald Head Point, and the results reported.

The suction-dredge Woodbury has been laid up at Campbell's Island during the whole year, under the care of a watchman. Her hull, house, and machinery have necessarily suffered some further deterioration from decay, rust, &c. Her boiler is known to be worthless; the engines and pumping apparatus are in reasonably good order.

A series of simultaneous tidal observations, begun in June, 1876, has been continued during the year, especially at Smithville and Campbell's Island.

The zero of reference at all the gauges is placed approximately at one level, by a careful study of the tidal movements. This is 24.55 feet below a bench-mark at the root and south side of the large live-oak tree in front of the Tremont House in Smith-

ville, or 26.75 feet below the floor of the front hall of the same house, or 25.16 below the top of the sun-dial stand in the garrison-yard.

The level is also preserved at the site of the light-house at Campbell's Island by nails driven into one of the piles to correspond to the number of feet above zero, as:
2 3 4 5
.. ..

It is also preserved at Federal Point by a bench on the center of the north end of the second crib, being the end of the base-line (A), which is 7.22 feet above zero of the gauge.

Simultaneous observations have been taken at the following places: Bald Head Point, (inside,) Smithville, at the "Clio," (about 2½ miles above Smithville,) Snow's Marsh, (opposite the New Inlet,) Zeke's Island, (at the old works, about 800 feet from the head,) Federal Point, Orton Creek, (Holmes' wharf,) and Campbell's Island. These results do not show the absolute range of the tides at the several places, (although they do it approximately,) but they exhibit the *relative* ranges to the extent of the observations.

These tidal observations will, on comparison with future observations which may be made at the same points after closing the New Inlet, show the effect of that work on the tidal movements.

PROBABLE OPERATIONS OF THE COMING FISCAL YEAR.

It is hoped that the present appropriation will be sufficient for the filling of the New Inlet dike to mean low-water. It is of the utmost importance for the security and permanence of the work that it should be completed to a height of at least 6 feet above mean low-water. There will be required for this, with the necessary additions to the slopes, from 16,000 to 22,000 cubic yards of stone. A portion for the facing and covering should be large stone from other quarries than Cape Fear River.

While the New Inlet is being closed it is earnestly recommended that the operations of nature be assisted by working a suction-dredge on the Bald Head Bar. This method of dredging is no longer an experiment, and is the best practical method for this place.

It is believed that the dredge Woodbury can be thoroughly repaired, with a new boiler, and in hull and house, and her machinery put in perfect order for $14,000. This seems a large estimate, but extensive repairs are required aside from the boiler.

The importance of assisting the natural forces to concentrate in establishing the Bald Head channel, at the critical time when they are to be increased by the closure of the New Inlet, calls for and justifies all reasonable expenditure therefor. The channel thus established would probably be permanent.

The dredging and widening of the upper end of the Horseshoe Cut is recommended.

The widening of the dredged channel just below the "Logs," and near Campbell's Island, to 250 feet width is also recommended.

The dredging in both these places is more expensive than the ordinary excavation in the river, as in the first place it is mostly compact sand, and at the other place a few logs and stumps are expected, as in the first cut.

Every reasonable precaution should be taken for the preservation of Smith's Island beach. A limited expenditure for the cultivation of beach-grass is recommended.

It is noticeable that the amount of the estimate for completing the closure of the New Inlet, with the amounts already expended for the same, of the former and present, and to be expended of the present appropriation, together with a reasonable allowance for superintendence and contingencies, does aggregate to $300,000, the original estimate of cost.

The following is an estimate for the expenditure of an appropriation of $160,000. It is hoped that the full amount will be granted:

16,000 cubic yards riprap stone from Cape Fear River for filling at New Inlet, at $2	$32,000
4,500 cubic yards large stone for facing, covering, and finishing New Inlet dike, (in place,) at $4	18,000
80,000 cubic yards dredging at channel below "Logs," at 30 cents	24,000
60,000 cubic yards dredging at Horseshoe Cut, at 30 cents	18,000
Repairs of suction-dredge	14,000
Operations of same eight months	8,000
Cultivation of beach-grass and repairs of Smith's Island beach	10,000
Repairs of old works, and superintendence and surveys	20,000
Contingencies	16,000
	160,000

Comparative results of simultaneous tidal observations in Cape Fear River, North Carolina, from June 6, 1876, to May 31, 1877.

	Smithville. Feet.	Federal Pt. Feet.
Smithville and Federal Point:		
From 184 simultaneous observations of high-water and 184 simultaneous observations of low-water:		
High-water average height above zero of gauge	4.88	4.50
Low-water average height above zero of gauge	0.39	0.62
Average range	4.49	3.88

	Smithville.	Campbell's Isl.
Smithville and Campbell's Island:		
From 230 simultaneous observations of high-water and 205 simultaneous observations of low-water:		
High-water average height above zero of gauge	4.94	4.54
Low-water average height above zero of gauge	0.53	0.91
Average range	4.41	3.63

	Federal Pt.	Campbell's Isl.
Federal Point and Campbell's Island:		
From 146 simultaneous observations of high-water and 135 simultaneous observations of low-water:		
High-water average height above zero of gauge	4.52	4.46
Low-water average height above zero of gauge	0.63	0.79
Average range	3.89	3.67

Highest tide observed at Smithville April 13, 1877 .... 8.10
Lowest tide observed at Smithville January 31, 1877 .... 0.95 below zero.
Highest tide observed at Federal Point April 13, 1877 .... 7.97
Lowest tide observed at Federal Point January 2, 1877 .... 0.45 below zero.

Respectfully submitted.

HENRY BACON,
Assistant Engineer.

Maj. WM. P. CRAIGHILL,
Corps of Engineers.

COMMERCE OF WILMINGTON, N. C.

A tabular statement of the principal articles of produce exported from the port of Wilmington, North Carolina, for the year ending December 31, 1872, as compiled from the reports of the Daily Journal, and compared with those of the years 1869, 1870, and 1871, prepared for and published in the Daily and Weekly Journal of that city.

Place.	Spirits turpentine.	Crude turpentine.	Rosin.	Tar.	Pitch.	Cotton.	Cotton yarn.	Cotton sheeting.	Peanuts.	Lumber, P. P.	Shingles.	Staves.	Shooks.
COASTWISE.	*Bbls.*	*Bbls.*	*Bbls.*	*Bbls.*	*Bbls.*	*Bales.*	*Bales.*	*Bales.*	*Bushels.*	*Feet.*			
New York, N. Y	32, 641	9, 696	307, 275	10, 660	1, 836	28, 586		1, 052	53, 832	144, 137	1, 095, 000	39, 932	1, 100
Salem, Mass			3, 743										
Kennybunkport, Me										680, 403			
Bath, Me										1, 451, 855			
Baltimore, Md	16, 850	587	63, 343	9, 219	3, 030	6, 627	18	121	17, 450	1, 581, 431	40, 150		
Philadelphia, Pa	7, 272	591	33, 430	4, 001	1, 500	9, 087	30	45	29, 805	5, 379, 201	2, 188, 636	96, 674	
Boston, Mass	1, 890	684	11, 991	8, 236	625	2, 435			2, 467	3, 655, 538			
Providence, R. I										1, 111, 041			
Richmond, Va	22		1, 159	190	45				96	62, 000			
Charleston, S. C	734		2, 003										
Thomaston, Me										270, 290			
Washington, D. C										286, 385			
Waldoboro', Me	1			2	6					449, 027			
Damariscotta, Me										500, 085			
Norfolk, Va			450	60	20								
Richmond, Me					10					310, 929			
Fall River, Mass										370, 085			
Georgetown, D. C										230, 219			
Alexandria, Va										71, 000			
Totals.													
Total 1872	59, 410	11, 558	493, 394	32, 368	7, 072	46, 717	48	1, 218	103, 680	16, 553, 716	3, 323, 795	136, 606	1, 100
Total 1871	55, 275	11, 392	415, 902	19, 376	3, 570	44, 919	236	946	54, 378	13, 104, 429	7, 475, 444	890, 210	
Total 1870	68, 966	12, 929	483, 546	54, 090	4, 624	51, 617	72	547	124, 296	11, 515, 123	4, 804, 890	842, 253	
Total 1869	54, 085	20, 537	506, 821	57, 900	4, 869	38, 449	28	489	118, 274	18, 177, 490	2, 191, 315	1, 558, 404	
FOREIGN.													
Fijardo										137, 616	50, 950		
Liverpool	8, 138	950	26, 778	1, 803		707				16, 200			
Queenstown, for orders	1, 335		2, 700										
Antwerp	1, 458		13, 161										

Cork, for orders	6,468		20,635										
Amsterdam	10,702		3,515										
St. Johns, P. R.	5			12	5					801,606	27,200		
Belfast	100		2,108										
London	14,690		10,819										
Cardenas				25	25					769,333			
Stettin			9,442										
Rotterdam	7,633		20,065										
Havana				10	1					708,771			
Bristol	3,450		10,609										
Ponce										223,585	95,959		
Cork or Falmouth, for orders	7,911		26,605										
Humacoa										169,607	175,000		
Arroyo										110,000	110,000		
Hamburg	2,700		27,218										
Cape Haytien										111,195	139,400		
Demarara	20			200	200					727,270			
South America										180,000			
Jamaica										70,054	250,000		
Saint Mark's	4		10	10	10					94,200			
Nassau				10	10					165,594	159,700		
Hayti										210,000			
Greenock	200		158	2,809									
Bermuda										150,281			
Cienfuegos										160,184			
Cork, Falmouth, or Plymouth, for orders			6,407										
Kingston										273,164	250,000		
Port au Platte										136,930			
Martinique										569,425	267,230		
Port au Prince	2			15	5					234,912			
Cronstadt			7,431										
Surinam	3			20	10					129,411			
Cuba										130,000			
Manzanilla										205,500			
Gonaives			5	5						41,538			
Bremen	1,150												
Matanzas										176,000			
Totals.													
Total 1872	77,969	950	196,666	4,919	275	707				6,710,436	1,534,439		
Total 1871	68,647	2,840	127,940	5,884	218					6,520,450	1,951,190		
Total 1870	32,889	3,258	26,127	6,107	190	20				8,378,861	2,339,334		
Total 1869	64,097	764	37,657	1,468	64	50			110	3,884,223	971,704	9,150	
GRAND TOTALS.													
1872	127,379	12,508	620,160	37,287	7,347	47,442	48	1,258	103,680	23,264,152	2,893,225	136,606	1,100
1871	123,922	14,232	543,109	25,260	3,788	44,919	236	946	54,378	19,624,879	9,426,634	890,230	
1870	101,855	16,187	509,673	60,197	6,814	51,637	72	547	124,296	19,893,981	7,144,224	482,235	
1869	111,182	21,301	554,473	59,370	4,933	38,499	28	496	118,384	22,011,643	3,163,106	1,588,404	

Statement of stocks, receipts and exports of cotton, spirits of turpentine, and rosins, Wilmington, North Carolina, for the years ending March 31, 1875, 1876, and 1877.

[Compiled by DeRosset & Co., shipping and commission merchants.]

STOCKS.

	Cotton.			Spirits turpentine.			Rosins.		
	1874–'75.	1875–'76.	1876–'77.	1874–'75.	1875–'76.	1876–'77.	1874–'75.	1875–'76.	1876–'77.
April	2,155	2,083	2,592	3,950	8,670	1,077	78,248	63,555	23,889
May	1,541	1,332	1,345	6,499	4,139	2,224	81,500	40,335	34,930
June	936	936	1,003	8,868	4,224	3,129	63,667	32,337	25,931
July	987	706	611	7,902	4,815	7,926	58,610	36,208	41,017
August	463	448	390	7,368	9,242	9,060	36,913	35,491	54,967
September	232	458	109	6,432	10,030	9,182	33,360	57,773	85,562
October	794	1,598	3,665	8,729	3,442	5,676	27,617	63,453	92,798
November	2,259	5,523	13,324	8,681	4,813	5,340	25,113	71,847	76,185
December	4,137	5,058	11,645	8,274	6,098	6,072	24,795	57,150	73,814
January	3,409	7,075	15,350	10,601	5,195	8,876	30,696	59,552	67,762
February	5,567	3,501	9,891	9,840	4,390	5,640	64,630	42,944	76,054
March	4,225	4,983	4,835	7,597	2,361	5,177	63,096	35,671	78,331
April	....	2,592	3,722	....	1,077	4,861	....	23,889	53,229

RECEIPTS AND MANUFACTURES.

	Cotton 1874–'75.	Cotton 1875–'76.	Cotton 1876–'77.	Spirits turpentine 1874–'75.	Spirits turpentine 1875–'76.	Spirits turpentine 1876–'77.	Rosins 1874–'75.	Rosins 1875–'76.	Rosins 1876–'77.
April	2,557	3,734	3,433	8,246	7,482	5,195	62,227	50,955	33,218
May	944	2,078	1,475	12,607	10,230	9,875	49,478	48,607	40,601
June	2,075	925	373	19,196	11,918	12,021	63,799	46,223	44,849
July	77	174	272	15,313	12,880	13,407	53,436	44,208	42,139
August	322	182	460	14,075	12,845	13,246	60,576	48,992	58,768
September	1,725	4,038	7,648	10,025	8,390	7,164	45,386	45,100	37,558
October	13,893	17,501	26,978	8,011	6,907	6,175	48,212	38,735	33,895
November	14,256	18,740	25,358	8,818	6,459	7,133	35,541	40,534	41,962
December	15,593	16,432	24,466	6,888	7,114	*8,085	43,648	45,541	33,940
January	9,434	7,925	13,859	6,059	4,730	6,015	53,764	47,296	64,564
February	8,094	8,628	8,043	4,198	4,186	4,428	42,138	48,254	41,994
March	6,909	4,143	3,551	7,532	4,056	4,667	47,316	36,283	51,479
Total	75,679	84,498	115,916	121,108	97,197	97,409	605,521	540,730	524,967

* Of which 1,113 barrels came by steamer from Charleston.

Statement of stocks, receipts, and exports of cotton, &c.—Continued.

EXPORTS—FOREIGN.

	Cotton.			Spirits turpentine.			Rosins.		
	1874-'75.	1875-'76.	1876-'77.	1874-'75.	1875-'76.	1876-'77.	1874-'75.	1875-'76.	1876-'77.
April	....	....	1,393	100	9,541	310	29,728	42,856	16,874
May	....	100	128	7,127	6,349	3,615	36,580	24,689	41,109
June	....	15	....	16,648	10,206	5,775	30,076	28,196	9,311
July	....	....	....	9,902	7,985	10,817	41,292	32,739	6,325
August	....	....	....	7,102	11,320	11,485	18,365	9,656	8,876
September	....	....	....	5,148	14,691	9,027	22,453	16,045	22,545
October	1,842	1,200	1,090	7,035	1,130	2,450	17,638	10,660	44,476
November	2,972	5,578	9,198	8,190	2,650	4,6[illegible]4	20,140	46,671	40,949
December	5,330	7,080	9,480	3,333	6,936	4,940	18,570	33,885	35,635
January	1,656	6,719	6,238	5,950	3,113	8,924	10,304	60,490	50,139
February	2,511	2,604	6,921	4,435	4,316	3,718	28,555	51,565	35,436
March	....	2,590	2,500	3,878	1,677	803	16,071	42,030	70,025
Total foreign	14,311	25,886	36,948	78,848	80,024	66,498	289,772	399,482	381,100

EXPORTS—DOMESTIC.

	Cotton.			Spirits turpentine.			Rosins.		
	1874-'75.	1875-'76.	1876-'77.	1874-'75.	1875-'76.	1876-'77.	1874-'75.	1875-'76.	1876-'77.
April	3,171	4,485	3,287	5,597	2,472	3,738	29,247	31,319	5,303
May	1,549	2,369	1,689	3,311	3,478	5,355	30,731	31,916	8,491
June	2,024	1,143	765	3,514	1,119	1,449	38,780	14,156	20,452
July	601	432	493	5,915	428	1,456	33,841	12,186	21,864
August	553	172	750	*7,909	717	1,639	*45,764	17,054	19,897
September	1,163	2,898	4,083	2,580	287	1,643	28,676	23,375	7,777
October	10,586	12,376	16,229	1,054	4,406	4,061	33,078	19,681	6,032
November	9,406	13,627	17,839	1,035	2,524	1,767	15,719	8,560	3,384
December	10,991	7,335	11,281	1,228	1,081	341	19,177	9,254	4,357
January	5,620	4,780	13,080	870	2,422	327	9,526	3,414	3,133
February	6,923	4,542	6,178	2,006	1,899	1,171	15,117	3,962	7,281
March	9,051	3,944	2,164	2,581	3,663	†4,180	30,786	6,037	†5,956
Total domestic	61,640	58,103	77,838	37,630	24,766	27,127	330,442	180,914	113,927
Total exports	75,951	83,989	114,786	116,478	104,790	93,625	620,214	580,396	495,027

* Including 2,144 spirits and 5,681 rosin destroyed by fire August 27, 1874.

† Including 13 spirits and 940 rosin destroyed by fire March 15, 1876.

Statement of stocks, receipts, and exports of cotton, &c.—Continued.

DESTINATION OF EXPORTS.

	1876–'77.			1875–'76.		
	Cotton.	Spirits.	Rosin.	Cotton.	Spirits.	Rosin.
New York	63, 674	17, 011	47, 616	46, 844	12, 990	117, 015
Baltimore	7, 165	8, 925	49, 752	8, 363	10, 246	43, 593
Philadelphia	18	50	2, 088	1, 000	636	7, 791
Boston	....	251	12, 259	20	567	10, 538
Other ports	6, 981	877	1, 272	1, 873	327	1, 977
Burnt	....	13	940	....	....	....
Total domestic	77, 838	27, 127	113, 927	58, 103	24, 766	180, 914
Cork, for orders	2, 773	28, 157	9, 863	....	3, 038	510
London	....	17, 803	61, 463	....	35, 075	57, 142
Liverpool	21, 058	127	29, 084	23, 585	7, 638	70, 854
Bristol	....	4, 127	20, 785	....	9, 741	26, 350
Glasgow	....	2, 600	44, 664	....	5, 600	40, 722
Hull	....	730	7, 382	....	360	4, 182
New Castle	....	300	9, 851	....	550	3, 476
Granton and Leith	....	1, 375	1, 045	....	....	18, 222
Belfast	....	300	1, 530	....	400	5, 505
Hamburg	....	1, 480	80, 323	1, 226	1, 550	45, 500
Rotterdam	....	500	43, 005	....	6, 893	59, 914
Amsterdam	7, 963	1, 331	....	1, 075	....	5, 672
Antwerp	775	6, 211	22, 080	....	8, 701	24, 007
Stettin	....	....	38, 837	....	....	17, 256
Bremen	1, 868	1, 365	500	....	500	2, 000
Dordrecht	....	....	....	....	....	2, 500
Cronstadt	....	....	....	....	....	5, 396
Trieste	....	....	8, 172	....	....	5, 004
Barcelona	....	....	....	....	....	1, 075
Cardiff	....	....	1, 700	....	....	....
Havre	2, 511	....	....	....	....	....
Other ports	....	92	816	....	38	265
Total foreign	36, 948	66, 498	381, 100	25, 836	80, 024	399, 482
Total exports	114, 786	93, 625	495, 027	83, 989	104, 790	580, 396

ANNUAL EXPORT TABLE.

Statement of the principal articles of produce and manufacture exported from the port of Wilmington, North Carolina, for the year ending December 31, 1876, and compared with the years 1875 and 1874; also the receipts of a few articles for the same period.

[Compiled by John L. Cantwell, secretary of the Wilmington Produce Exchange.]

DOMESTIC.

Destination.	Sundries.							Barrels.		
	Lumber.	Shingles.	Railroad ties.	Juniper bolts.	Ores and metals.	Mica.	Barytes.	Spirits turpentine.	Rosin.	Tar.
Baltimore	2, 271, 422	1, 034, 050	....	10, 500	42, 942	..	..	10, 730	48, 625	15, 540
Bath	599, 019	....	....	....	....	..	457	.. ..	....	125
Boston	109, 215	....	....	....	....	..	...	100	9, 961	4, 351
Camden	150, 124	....	....	....	....	..	...	....	....	....
Kennebunk	564, 813	....	....	....	....	..	...	....	....	....
New Bedford	....	....	....	....	....	..	...	....	....	1, 000
New York	122, 550	1, 207, 950	....	8, 000	99, 701	4	230	17, 698	49, 181	11, 561
Perth Amboy	394, 345	....	....	....	....	..	...	....	....	....
Philadelphia	832, 575	721, 225	....	37, 032	908, 120	..	...	52	1, 033	400
Portland	527, 643	....	....	....	....	..	...	....	....	....
Providence	150, 566	....	....	....	....	..	...	....	....	....
Rockport	270, 527	....	....	....	....	..	...	....	....	....
Richmond	225, 000	....	....	....	....	..	...	....	....	....
Thomaston	669, 210	....	....	....	....	..	...	....	3	2
Waldoboro'	245, 067	....	....	....	....	..	...	....	....	....
Wilmington	281, 460	....	....	....	....	..	...	....	....	....
Yarmouth	153, 236	....	....	....	....	..	...	....	....	....
Sundry and railroads	3, 000	....	....	....	1, 600, 097	..	...	853	2, 167	998
Total, 1876	7, 575, 772	2, 963, 225	....	55, 532	2, 650, 860	4	687	29, 433	110, 970	34, 106
Total, 1875	3, 916, 066	3, 330, 200	....	76, 889	664	..	...	22, 239	122, 930	30, 540
Total, 1874	9, 998, 295	5, 432, 408	....	110, 476	8, 741	..	...	42, 702	307, 758	47, 839

Statement of the principal articles exported from Wilmington, N. C., &c.—Continued.

FOREIGN.

Destination.	Sundries.							Barrels.		
	Lumber.	Shingles.	Railroad ties.	Juniper bolts.	Ores and metals.	Mica.	Barytes.	Spirits turpentine.	Rosin.	Tar.
Amsterdam								1, 331		
Antwerp								7, 677	21, 139	
Arroyo	218, 994	189, 300						1		13
Barbadoes	200, 000									
Belfast								700	5, 254	
Bremen								1, 365	500	
Bristol								4, 094	23, 445	
Cardenas	400, 710							4		161
Cape Haytien	192, 093	106, 915								
Cork, Queenstown, or Falmouth, G. B., for orders								17, 067	6, 782	2, 152
Cronstadt									2, 326	
Demarara	340, 516									129
Funchal	195, 048									
Glasgow								2, 500	45, 144	2, 510
Grenada	117, 076									
Greenock										1, 927
Hamburg								1, 560	72, 397	
Harbor Island	20, 339	65, 000						1		4
Havana			3, 816					5		71
Honduras	37, 557	50, 000						5		10
Hull								730	5, 632	7, 153
Hayti	192, 000	17, 000								
Jackmel	134, 372	56, 575								
Jeremie	467, 889	322, 015						20		
Laguayra	533, 427								600	
Leith								1, 375	1, 045	
Liverpool	7, 079								40, 628	13, 587
London								22, 807	71, 532	
Mayagues	180, 630	80, 600								
New Castle								850	10, 687	
Point a Petre	169, 941	44, 250								
Ponce	766, 692	323, 900								
Port au Prince	1, 552, 435	460, 500						11		45
Port de Paix	78, 711	40, 000								
Rio de Janeiro	737, 935									
Rotterdam									49, 855	
Santiago de Cuba	160, 721								157	
Stettin									17, 447	
St. Martins and Nevis	64, 207	117, 800						1	6	8
St. Pierre	235, 846	54, 700								
Surinam	118, 642							55	5	25
Trieste									5, 004	
Total, 1876	8, 122, 860	1, 926, 555	3, 816					62, 159	379, 585	27, 785
Total, 1875	5, 904, 541	1, 859, 000	12, 113					85, 181	300, 400	16, 619
Total, 1874	4, 231, 030	3, 087, 805	22, 898					83, 129	248, 424	20, 799

GRAND TOTALS, COAST AND FOREIGN.

Total, 1876	15, 698, 632	4, 889, 780	3, 816	55, 532	2, 650, 860	4	687	91, 592	490, 555	61, 891
Total, 1875	9, 820, 607	5, 189, 200	12, 113	76, 889	664			107, 420	523, 330	47, 159
Total, 1874	14, 229, 325	8, 520, 213	22, 898	116, 476	8, 741			125, 837	556, 182	

RECEIPTS.

Total, 1876								94, 273	498, 765	64, 441
Total, 1875								102, 014	552, 113	47, 159
Total, 1874								128, 516	641, 140	68, 619

Statement of the principal articles exported from Wilmington, N. C., &c.—**Continued.**

DOMESTIC.

Destination.	Barrels.													
	Crude turpentine.	Pitch.	Rosin-oil.	Eggs.	Vegetables.	Liquors.	Bottles.	Wines.	Apple and peach brandy.	Rice.	Hominy.	Flour.	Molasses.	Sugar.
Baltimore	796	3,867	94	35	71	53	23	6	48	1				
Bath		25												
Boston	250	945	10											
Kennebunk		51												
New York	2,821	531	4	118	18	8	24	4						
Thomaston		12												
Sundry and railroads	33	331	9	2	795	102		7	1	46	21	4	132	36
Total, 1876	3,900	5,762	117	155	884	163	47	17	49	47	21	4	132	36
Total, 1875	7,955	3,994	156	65	63	49				157		15		
Total, 1874	14,945	7,316	143	175		145				298		261		

FOREIGN.

Destination.	Crude turpentine.	Pitch.	Rosin-oil.	Eggs.	Vegetables.	Liquors.	Bottles.	Wines.	Apple and peach brandy.	Rice.	Hominy.	Flour.	Molasses.	Sugar.
Cardenas		45												
Demarara		200												
Harbor Island		4			7							60		
Jeremie			100											
Liverpool	1,535													
Port au Prince		10												
St. Martins and Nevis		7												
Surinam		50												
Total, 1876	1,535	316	100		7							60		
Total, 1875	339	182												
Total, 1874	650	167												

GRAND TOTALS, COAST AND FOREIGN.

Destination.	Crude turpentine.	Pitch.	Rosin-oil.	Eggs.	Vegetables.	Liquors.	Bottles.	Wines.	Apple and peach brandy.	Rice.	Hominy.	Flour.	Molasses.	Sugar.
Total, 1876	5,435	6,078	217	155	891	173	47	17	49	47	21	64	132	36
Total, 1875	8,294	4,176	156	65	63	49				157		15		
Total, 1874		7,483	153	175		145				298		261		

RECEIPTS.

Destination.	Crude turpentine.	Pitch.	Rosin-oil.	Eggs.	Vegetables.	Liquors.	Bottles.	Wines.	Apple and peach brandy.	Rice.	Hominy.	Flour.	Molasses.	Sugar.
Total, 1876	119,617													
Total, 1875	82,974													
Total, 1874	15,575													

DOMESTIC.

Destination.	Barrels.			Hogsheads.			Bushels.		Cases.		Bundles.	
	Fish.	Bacon.	Lime.	Molasses.	Bones.	Empty barrels, kegs, hogsheads, and tierces.	Peanuts.	Cow-peas.	Spirits turpentine.	Tar.	Cotton-ties.	Bags.
Baltimore					20	1,313	29,924	88	392	1,402	6	40
Boston										25		
New York	1			54	14	418	8,083	256	55	82		[illegible]
Philadelphia				69								21
Sundry and railroads	363	15	18	205	10	879	6,398	11	6		292	26
Total, 1876	364	15	18	328	44	2,610	44,405	355	453	1,515	298	95
Total, 1875				172		1,360	41,138	1,340	225	770		
Total, 1874				568		3,111	33,562	825	376	717	600	

Statement of the principal articles exported from Wilmington, N. C., &c.—Continued.

FOREIGN.

Destination.	Barrels.			Hogsheads.			Bushels.		Cases.		Bundles.	
	Fish.	Bacon.	Lime.	Molasses.	Bones.	Empty barrels, kegs, hogsheads, and tierces.	Peanuts.	Cow-peas.	Spir.ts turpentine.	Tar.	Cotton-ties.	Bags.
Cardenas						1,579						
Harbor Island		3										
Havana						79	50					
Jeremie									20			
Port de Paix									250			
Total, 1876						1,658			270			
Total, 1875						511					12,113	
Total, 1874						150					22,898	

GRAND TOTALS, COAST AND FOREIGN.

Destination.	Fish.	Bacon.	Lime.	Molasses.	Bones.	Empty barrels, kegs, hogsheads, and tierces.	Peanuts.	Cow-peas.	Spir.ts turpentine.	Tar.	Cotton-ties.	Bags.
Total, 1876	36	15	18	328	44	4,268	44,455	355	453	1,515	298	95
Total, 1875				172		1,861	41,138	1,340	225	770		
Total, 1874				568		3,261	33,562	825	376	717	400	

DOMESTIC.

Destination.	Bundles.		Bales.						Packages.		
	Paper.	Hides.	Cotton.	Cotton goods.	Yarns.	Waste.	Wool.	Rags.	Roots and herbs.	Moss.	Tobacco.
Baltimore	236	67	7,834	1,167	3,621	145	151	219	310	7	14
New York	543	63	54,096	1,816	382		28	33	728		21
Philadelphia			56								
Providence			165								
Sundry and railroads	176	847	7,531	528	73	12		195	1		26
Total, 1876	1,007	977	69,682	3,511	4,076	157	179	447	1,039	7	61
Total, 1875	1,841	270	53,123	1,984	1,260		98	246	224		40
Total, 1874	332	3,570	52,635	2,375	1,095		138	399			714

FOREIGN.

Destination.	Paper.	Hides.	Cotton.	Cotton goods.	Yarns.	Waste.	Wool.	Rags.	Roots and herbs.	Moss.	Tobacco.
Amsterdam			3,289								
Antwerp			775								
Bremen			1,868								
Cork, Queenstown, or Falmouth, G. B., for orders			2,773								
Havre			1,011								
Liverpool			23,486	11							
Total, 1876			33,202	11							
Total, 1875			18,140								
Total, 1874			11,927	3	26						

GRAND TOTALS, COAST AND FOREIGN.

Destination.	Paper.	Hides.	Cotton.	Cotton goods.	Yarns.	Waste.	Wool.	Rags.	Roots and herbs.	Moss.	Tobacco.
Total, 1876	1,007	977	102,884	3,522	4,076	157	179	447	1,039	7	61
Total, 1875	1,841	270	71,262	1,984	1,260		98	246	224		40
Total, 1874	332	3,570	63,562	2,378	1,121		138	399			714

RECEIPTS.

Destination.	Paper.	Hides.	Cotton.	Cotton goods.	Yarns.	Waste.	Wool.	Rags.	Roots and herbs.	Moss.	Tobacco.
Total, 1876			111,434								
Total, 1875			88,839								
Total, 1874			67,150								

Statement of the principal articles exported from Wilmington, N. C., &c.—Continued.

DOMESTIC.

Destination.	Packages.								Rolls.		Bags.		
	Beeswax.	Merchandise.	Furs.	Shooks.	Rope.	Fruit.	Dried fruit.	Feathers.	Leather.	Bagging.	Coffee.	Guano.	Salt.
Baltimore	31	988	3	4	1		814	50	310	2		1,036	
New York	74	1,644	40	8,774	2		385		31				
Sundry and railroads	3	900			13	124				34	58	2,517	1,349
Total, 1876	108	3,532	43	8,778	16	124	1,199	50	341	36	58	3,553	1,349
Total, 1875	44	1,318	12	7,430			186		39			438	
Total, 1874	285	2,363		9,714			617		683				

FOREIGN.

Destination.	Beeswax.	Merchandise.	Furs.	Shooks.	Rope.	Fruit.	Dried fruit.	Feathers.	Leather.	Bagging.	Coffee.	Guano.	Salt.
Harbor Island		24											
Havana		30											
Point a Petre												24	
St. Pierre												24	
Total, 1876		34										48	

GRAND TOTALS, COAST AND FOREIGN.

	Beeswax.	Merchandise.	Furs.	Shooks.	Rope.	Fruit.	Dried fruit.	Feathers.	Leather.	Bagging.	Coffee.	Guano.	Salt.
Total, 1876	108	3,532	43	8,778	16	124	1,119	50	341	36	58	3,553	1,349
Total, 1875	44	1,719	12	7,430		186			39			438	
Total, 1874	285	2,353		4,714		617			683				

Statement of exports from the district of Wilmington, North Carolina, to foreign countries from January 1, 1871, to December 31, 1876, inclusive.

Year.	Cotton.		Rosin and turpentine.		Tar and pitch.		Spirits turpentine.		Lumber.	
	Bales.	*Value.*	*Barrels.*	*Value*	*Barrels*	*Value.*	*Barrels.*	*Value.*	*M feet.*	*Value.*
1871	61	$4,061	132,812	$404,853	6,080	$12,026	46,800	$1,021,675	6,946	$135,4[illegible]
1872	707	55,832	189,332	784,258	5,184	16,133	73,030	1,788,403	7,137	156,[illegible]
1873	4,555	296,491	367,379	1,152,880	4,510	14,612	93,157	1,806,855	7,103	15[illegible]
1874	12,124	741,926	175,629	943,289	19,419	46,650	84,009	1,347,462	4,816	96,930
1875	18,141	1,088,065	100,043	630,831	17,866	32,395	85,890	1,250,531	7,123	12[illegible],272
1876	32,202	1,782,684	187,851	766,685	25,243	44,589	65,057	898,793	7,148	121,034

Year.	Shingles.		Railroad-ties.		Lath.		Empty hogsheads and barrels.		Brick.		Staves.	
	M.	*Value.*	*No.*	*Value.*	*M.*	*Value.*	*No.*	*Value.*	*M.*	*Value.*	*No.*	*Value.*
1871	1,808	$10,303	22,052	$10,556			16	$12	20,000	$220		
1872	1,803	12,341	4,241	2,120								
1873	2,447	15,737	15,861	8,132	10	$30	125	125				
1874	2,223	14,995	35,919	19,896			1,096	1,331				
1875	2,115	12,926	8,500	3,725			1,047	1,503	15,000	197		
1876	1,871	10,567	3,816	2,008	300	1,800	1,184	1,414			29,700	$[illegible]

Year.	Cow peas.		Spars.		Nails.		Potatoes.		Mineral oil.		Rope.	
	Bush.	*Value.*	*No.*	*Value.*	*Lbs.*	*Value.*	*Bbls.*	*Value*	*Galls.*	*Value.*	*Lbs.*	*Value.*
1871												
1872	20	$25	1	$186								
1873					2,900	$174						
1874	25	35	5	125			14	$42	100	$40	2,154	$463
1875	39	43			4,958	127	4	10	1,000	190		
1876	40	42	4	350			4	10				

Statement of exports from the district of Wilmington, N. C., &c.—Continued.

Year.	Cotton goods.		Gold.	Oakum.		Mackerel.		Salt pork.		Flour.	
	Yards.	*Value.*		*Cwt.*	*Value.*	*Kits.*	*Value.*	*Bbls.*	*Value.*	*Bbls.*	*Value.*
1871			$10,000								
1872											
1873											
1874	616	$190		12	$133	34	$93				
1875								100	$2,250	30	$210
1876	152,557	11,258								60	360

Year.	Bacon.		Boots and shoes		Tobacco.		Guano.		Hats.		Paint.	
	Lbs.	*Value.*	*Cases.*	*Value.*	*Lbs.*	*Value.*	*Tons.*	*Value.*	*Doz.*	*Value.*	*Galls.*	*Value.*
1871												
1872												
1873												
1874												
1875			5	$222	132	$66					107	$267
1876	1,626	$168	10	432	129	65	4	$240	68	$566		

R. W. CHADWICK,
Deputy Collector.

CUSTOM-HOUSE, *Wilmington, April* 13, 1877.

HARBOR-MASTER'S REPORT FOR 1874, 1875, AND 1876.

1874.

	American vessels.	Tonnage.
Steamers	197	125,138
Barks		
Brigs	15	3,179
Schooners	209	50,481
Total	421	178,798

	Foreign vessels.	Tonnage.
Steamers	1	40
Barks	101	31,581
Brigs	80	19,336
Schooners	10	2,179
Total	192	53,136

Total arrivals, American and foreign, 613. Total tonnage, American and foreign, 231,934.

1875.

	American vessels.	Tonnage.
Steamers	119	75,771
Barks		
Brigs	17	4,243
Schooners	81	18,985
Total	217	98,999

	Foreign vessels.	Tonnage.
Steamers	1	200
Barks	73	24,432
Brigs	56	14,948
Schooners	3	759
Total	133	40,339

Total arrivals, American and foreign, 350. Total tonnage, American and foreign, 139,338.

1876.

	American vessels.	Tonnage.
Steamers	157	104,742
Barks	1	400
Brigs	10	2,244
Schooners	120	28,855
Total	288	136,241

	Foreign vessels.	Tonnage.
Steamers	1	50
Barks	124	41,530
Brigs	74	19,771
Schooners	6	804
Total	205	62,155

Total arrivals, American and foreign, 493. Total tonnage, American and foreign, 198,396.

COMPARATIVE STATEMENT OF THE RECEIPTS AND EXPORTS OF COTTON AND NAVAL STORES AT THE PORT OF WILMINGTON, NORTH CAROLINA, FOR THE YEARS ENDING MARCH 31, 1876 AND 1877.

Receipts.

	Cotton.	Spirits of turpentine.	Rosin.	Tar.	Crude turpentine.
	Bales.	*Bbls.*	*Bbls.*	*Bbls.*	*Bbls.*
For the year ending March 31, 1876	84,518	97,197	540,730	53,010	86,833
For the year ending March 31, 1877	115,916	97,409	524,967	71,211	143,[illegible]

Exports, domestic.

	Cotton.	Spirits of turpentine.	Rosin.	Tar.	Crude turpentine.
For the year ending March 31, 1876	58,103	24,701	180,689	34,770	7,012
For the year ending March 31, 1877	77,838	27,127	113,927	38,478	4,450

Exports, foreign.

	Cotton.	Spirits of turpentine.	Rosin.	Tar.	Crude turpentine.
For the year ending March 31, 1876	25,886	80,024	399,480	31,554	391
For the year ending March 31, 1877	36,948	66,498	381,100	33,476	2,328

Total exports, domestic and foreign.

	Cotton.	Spirits of turpentine.	Rosin.	Tar.	Crude turpentine.
For the year ending March 31, 1876	83,989	104,725	580,169	66,324	7,403
For the year ending March 31, 1877	114,786	93,625	495,027	71,954	6,778

Stocks.

	Cotton.	Spirits of turpentine.	Rosin.	Tar.	Crude turpentine.
For the year ending March 31, 1876	2,592	1,077	23,889	8,160	5,038
For the year ending March 31, 1877	3,722	4,861	53,829	7,404	5,016

JNO. L. CANTWELL,
Secretary.

CHAMBER OF COMMERCE,
Wilmington, N. C., April 2, 1877.

APPENDIX G.

ANNUAL REPORT OF MR. S. T. ABERT, UNITED STATES CIVIL ENGINEER, FOR THE FISCAL YEAR ENDING JUNE 30, 1877.

UNITED STATES ENGINEER OFFICE,
Washington, D. C., July 21, 1877.

GENERAL: I have the honor to submit herewith my annual report relating to the works of river and harbor improvement under my charge for the fiscal year ending June 30, 1877.

Very respectfully, your obedient servant,

S. T. ABERT,
United States Civil Engineer.

Brig. Gen. A. A. HUMPHREYS.
Chief of Engineers, U. S. A.

G 1.

IMPROVEMENT OF WASHINGTON AND GEORGETOWN HARBORS, DISTRICT OF COLUMBIA.

The operations with the diamond drill, in the harbor of Georgetown, were continued until August 15, when the machinery was towed to the James River, near Richmond. The balance of the appropriation, being too small for the continuation of the improvement, can be expended in making examinations of the channel between the aqueduct and Giesboro Point, in order to ascertain the changes which are taking place, and also for the purpose of obtaining data for estimating the amount of dredging required for the preservation of the navigation. I subjoin a detailed history of operations since my last report.

The diamond drill of the American Diamond Drill Company was used in removing rock. The same machine had been used upon the James River, below Richmond, and was kindly loaned to me by Col. Wm. P. Craighill, of the Corps of Engineers.

DETAILED DESCRIPTION OF THE WORK, WITH ANALYSIS OF COST—METHOD OF WORKING.

The plant consisted of—

1. *A hoister*, which was a scow (65′ × 23′) with a derrick and hoisting-engine.
2. *A drilling-platform*, (16′ × 18′) supported on four inclined spuds, connected with the platform by suitable gearing.
3. *Two drilling-engines*, for operating the diamond drill.
4. *A boiler-lighter*, with a boiler for supplying steam to the drilling-engine.
5. *A small lighter*, for the use of the divers; and,
6. *A stone-scow*, for the removal of the rock.

The rock to be removed was first carefully examined, and the location, direction, and length of the drill-holes determined upon. The drilling-platform was then set at high tide, the spuds being made fast to the platform, so that as the tide fell it rested upon them. The drilling-engine was then placed in position on the edge of the platform, and connected with the boiler on the boiler-lighter by a flexible steam-hose. The engine was run at a high rate of speed, but the power was so small that any serious obstruction would stop it without injury to the diamonds. The rate of drilling was, on an average, 30 inches per hour. After the hole was drilled the platform was removed, and the tin cartridges, containing the nitro-glycerine, placed in it by the diver. A water-tight exploder of fulminate of mercury having previously been introduced, the cartridge was closed by a wooden plug, the gutta-percha covered wire from the exploder passing through the plug. No tamping was used other than some old rope, or waste, around the top of the cartridge. The lighters, &c., having been removed to a safe distance, the charge was fired by a frictional battery.

The removal of the rock was then commenced, the pieces being hoisted by means of chains placed about them by the diver, and then placed on the scow. It was found that the most economical work can be done when the pieces contain from 1 to 2 yards. The diver can place the chain about the rock more easily, and there is, therefore, less delay. Masses of over 4 cubic yards, weighing 10½ tons, have been raised, but the strain on the machinery was very great, particularly after the stone had left the water. Small pieces were placed on an iron grating by the diver, and raised in this way. This, however, is a slow operation, as it is difficult for the diver to move rapidly under water.

ROCK A.

This rock was situated in the center of the stream, a short distance below the Aqueduct bridge. Work was commenced on it March 17. A drift log, some 35 feet long, and about 2 feet in diameter, was found lodged on it. On attempting to set the drilling-platform, it was found that the rock was surrounded by very soft mud, into which the spuds sank so far that it was found necessary to lengthen them. This having been done, work was actively commenced. The rock was found to be a very hard and tough granitic rock; it broke into wedge-shaped pieces, with smooth faces. The rock weighed 183.75 pounds per cubic foot. Operations on this rock were interrupted by a freshet, which began March 28 and continued several days. The work was continued until April 12, when there was a depth of from 17 to 18 feet over the rock at low-water, somewhat more than was found on the mud bottom of the river above the rock. Sixty-one feet of holes were drilled, at an average rate of 2.4 feet per hour; 61.4 cubic yards of rock were removed. The average amount of nitro-glycerine per yard of rock was 0.85 pounds, 52½ pounds being used on the entire rock. This includes that used in "flat cartridges"—used for opening cracks and seams

The following table exhibits the work of the drill in detail:

ROCK A.—*Tabular statement of operations.*

Designation.	Holes drilled. Depth.	Diameter.	Time of drilling.	Rate in feet per hour.	Number of fuit cartridges.	Quantity of nitro-glycerine.	Remarks.
	Feet.	*Inches.*	*Hours.*			*Lbs.*	
1	14	2½	5½	2.55	....	11	Commenced March 20.
2	3	2½	1½	2.00	....	2	
....	......	......	......	......	4	2	
3	3	2½	1½	2.00	....	2	
....	......	......	......	......	4	6	
4	7	2½	3	2.33	....	3½	
5	5	2½	2	2.50	....	2½	
6	6	2½	2½	2.40	....	3	
7	4	2½	2	2.0	...	2	
....	......	......	......	......	4	4	
8	6	2½	2	3.0	....	3	
9	6	2½	2	3.0	....	3	
10	7	2½	3	2.33	....	3½	
....	......	......	......	......	4	5	Completed April 12.
Total	61	......	25	......	16	52½	

Average rate of drilling per hour = 2.4 feet.
Average amonnt of nitro-glycerine per yard of rock = 0.85 pounds.
Number cubic yards of rock removed. 61.4.

ROCK B.

Rock B was situated near the middle of the river, opposite the mill-race. A survey was made of it, and its contour is shown on the accompanying plan. The least depth over it was 5.7 feet, and its location was such as to render it the most dangerous obstruction to navigation in the harbor. Its length at the 16-foot curve was about 52 feet, and the width averaged 28 feet. Work was commenced April 13. The rock was found to be granitic, very irregular in its composition, containing many masses of pure quartz and of mica. On the top of the rock the mica had been washed out by the action of the water, and the hollow pockets presented a honey-combed appearance. Frequent natural seams in the rock made the drilling difficult. In blasting it was found that, owing to the peculiar composition of the rock, it broke into small pieces; rendering it more expensive to raise.

The force of the explosive seemed to be expended in breaking the rock into powder or small fragments, rather than into the comparatively large masses required for economical handling.

Work was continued on this rock until June 6, when, owing to the accumulation of sand and *débris*, dredging was found necessary, and the force was transferred to G-street rock. Application was made for the use of the dredge at the navy-yard, which was granted. The dredge having been fitted up, work was resumed July 6. When sufficient dredging had been done, work was resumed with the drill and hoister, and continued until July 29, when a depth of 16 feet at low-water was attained over the whole rock, and operations were discontinued.

The following table exhibits in detail the work of the drills and the result attained.

ROCK B.—*Tabular statement of operations.*

Designation.	Holes drilled. Depth.	Holes drilled. Diameter.	Holes drilled. Time of drilling.	Holes drilled. Average rate in feet per hour.	Number of flat torpedoes.	Number pounds of nitro-glycerine.	Remarks.
	Feet.	*Inches.*	*Hours.*				
1	15	2½	6½	2.3	...	40 (1 and 2)	
2	15	2½	6½	2.3	7		
3	10	4	6	1.67	....	12	
	.....	....	....	.....	7	6	
4	14	2½	7	2	...	12	
5	11	2½	5	2.2	...	7	
6	11	2½	5	2.2	....	6	
	.....	....	....	.....	6	6	
7	11	2½	5	2.2	....	11½	
8	9	2½	4	2.25	....	8	
	.....	....	....	.....	5	3	
9	11	2½	6	1.83	....	11	
10	9	2½	5	1.8	....	6	
	.....	....	....	.....	7	5	
11	9	2½	4	2.25	...	10	
12	13	2½	5	2.6	...	13	
	.....	....	....	.....	8	6	
13	8	2½	3	2.67	....	6	
14	9	2½	4	2.25	....	8	
	.....	....	....	.....	5	3	
15	8	2½	2½	3.2	....	5	
	.....	....	....	.....	2	1½	Work suspended.
16	5	2½	1½	3.33	....	3	Work resumed.
17	10	2½	3½	2.85	....	10	
18	10	2½	4	2.50	....	10	
19	9	2½	3½	2.57	....	6	
20	9	2½	3½	2.57	....	6	
	.....	....	....	.....	3	3	
21	5	2½	1½	3.33	....	5	
22	4	2½	1½	2.67	....	5	
	.....	....	....	.....	8	9	
Total, (2½ inches)	205	....	87½	......	....	243	
Total 4-inch holes	10	....	6	......	....	......	

Average rate of drilling per hour, 2.34 feet.
Average amount of nitro-glycerine per yard of rock, 0.76 pound.
Number of cubic yards of rock removed, 317.3.

ROCK G.

This rock is off the foot of G street, and has been a dangerous obstruction to navigation. The least depth of water over it was 3.1 feet. Work was commenced June 7, but on June 13 the mast of the derrick, which had become decayed by long use, gave way, causing a delay of a week, and involving a large expenditure for repairs. Work was suspended July 5, to complete rock B, resumed July 31, and continued until August 15.

The rock was found to be a hard granitic rock of uniform texture, breaking easily into masses of the most convenient size. The depth attained over this rock was 10 feet at low-water. It was intended to secure at least 13 feet, but the necessity for the return of the machinery to Richmond prevented further work. The following table exhibits the result attained:

ROCK G.—*Tabular statement of operations.*

Designation.	Holes drilled.				Number of flat torpedoes.	Number pounds of nitro-glycerine.
	Depth.	Diameter.	Time of drilling.	Rate in feet per hour.		
	Feet.	*Inches.*	*Hours.*			
1	14	2¼	5	2.8	......	13
	......	2¼	......	......	......	1
	......	2¼	......	......	2	2
2	10	2¼	4	2.5	......	7½
3	12	2½	5	2.4	......	12
	......	2¼	......	......	7	4½
	......	2¼	......	......	6	11
	......	2¼	......	......	5	5
4	5	2¼	1½	3.33	......	2½
5	4	2¼	1½	2.67	......	2½
	......	2¼	......	......	2	1
6	6½	2¼	2½	2.60	......	4
	......	2¼	......	......	8	8
Total	51½	......	19½	......	......	75

Average rate of drilling per hour, 2.64 feet.
Average amount of glycerine per cubic yard of rock, 0.52 pounds.
Number of cubic yards of rock removed, 143.3.

The following table shows the amount of nitro-glycerine made each month, with the cost of the same:

Month.	Number of pounds of mixed acid used.	Number of pounds of glycerine used.	Resulting amount of nitro-glycerine.	Number of pounds of acid per pound of glycerine.	Number of pounds of glycerine per pound of nitro-glycerine.	Cost of materials per pound.
March	320	32	54	5.9	0.59	$0 58½
April	335	32	63	5.3	0.51	57
May	810	82	140	5.8	0.58	62
June	400	40	73	5.5	0.55	61
July	274	27	48	5.7	0.56	63
August	150	15	27	5.6	0.56	......
Total	......	......	405	......	......	......
Average	......	......	......	5.6	0.56	......

The amount of acid per pound of glycerine is 5.6 pounds, and of glycerine one-tenth of this amount, .56 pounds.

The amount of nitro-glycerine used per yard of rock was 0.26 pound. The amount used per yard for each rock is exhibited in the following table, which also shows the length of hole drilled per yard of rock removed:

Designation.	Character of rock.	Feet of hole per yard of rock.	No. of pounds of glycerine per yard of rock.
A	Granite, very tough and hard	1.0	0.85
B	Granite, irregular and soft	0.68	0.76
G	Granite, firm; easily broken	0.36	0.52

It appears from this table that a firm (but not tough) rock, like ro[illegible] G, which breaks in large masses, can be more economically remov[illegible] than a much softer rock, like rock B.

COST OF THE WORK.

The total amount of rock removed was 522 cubic yards. The deta[illegible] of the cost are shown in the following table, from which it appears t[illegible] total cost per cubic yard was $14.36, of which $2.08 was for the trans[illegible] of machinery from Richmond and return, $2.10 for extraordinary repa[illegible] and $10.18 for actual cost of removal. This latter item is made up [illegible] follows:

	Per cub.
Labor	$[illegible]
Explosives, cartridges, &c	[illegible]
Repairs to drill, iron-work, &c	[illegible]
Supplies, rope, diving-dresses, &c	[illegible]
Rent and towing	[illegible]
Coal	[illegible]
Total	10[illegible]

Cost of rock work, Georgetown Harbor.

Designation.	Transfer from Richmond and return.	Extraordinary repairs to machinery.	Removal of rock, including ordinary repairs and supplies.	Tot[illegible]
Labor	$601 12	$440 90	$4,209 44	$5,23[illegible]
Explosives			265 76	26[illegible]
Cartridges, &c			116 40	11[illegible]
Repairs to drill, and iron-work		377 79	211 16	[illegible]
Diving-dresses			89 35	[illegible]
Lumber	42 12	113 22		15[illegible]
Coal			155 50	15[illegible]
Supplies	10 02		88 03	9[illegible]
Rope			92 92	9[illegible]
Rent			52 00	5[illegible]
Towing	427 74		33 00	46[illegible]
Use of air-pump		168 00		16[illegible]
Total	1,083 00	1,099 91	5,313 56	7,49[illegible]
Per cubic yard	2 08	2 10	10 18	14 [illegible]

Amount of rock removed 5,226 yards.

FURTHER OPERATIONS.

Georgetown Channel.

In my last report it was stated that the plan of the Board, submitte[illegible] to Congress December 17, 1872, for effecting a radical and complet[illegible] improvement of the harbor, might be carried out in parts, so that eac[illegible] part would in itself be an efficient improvement. It was recommende[illegible] that the first part to be improved should be limited to that portion o[illegible] the river between G street and Easby's Point. The total amount of th[illegible] estimate was $686,000. No appropriation was made, but what has bee[illegible] urged in regard to the importance of the work remains unchanged.

Plan of

ETOWN HARBOR D.C.

rom a survey made in 1871
under the direction of
CRAIGHILL Corps of Engineers U.S.A.
work done in 1876 in the removal of rock
under the direction of
S.T. ABERT U.S. Civ. Engr.

Scale.

The main ship-channel between the Long Bridge and Analostan Island cannot be passed by the heaviest-draught coal-vessels, which land at the coal wharves at Georgetown. The larger part of the trade which passes through this channel is made up of Cumberland coal, which is shipped to New York, Boston, Philadelphia, and used extensively by steam-vessels and for manufacturing purposes. The annual shipments amount to 680,000 tons, all of which pass through the Georgetown Channel. For dredging this channel, with a width of 250 feet and a depth of 18 feet at low-water, the following estimate is submitted:

213,300 cubic yards, at 18 cents per yard	$38,394
Contingencies, 10 per cent	3,839
	42,233

Washington Channel.

The Washington Channel of the Potomac, between the Arsenal and the south draw of the Long Bridge, has become very shoal, so as to offer considerable obstruction to vessels attempting to reach the wharves of the city. The following table, prepared by Capt. J. H. Johnson, shows the condition of the channel during the past fifteen years, and the improvement made along the city front, and the amount of material landed.

Years.	Average draught of vessels employed, carrying-trade.	Average depth of water in river.	Number of steamers and tugs employed.	Capital invested in steam-vessels.	Tonnage of vessels employed.	Number of wharves between Arsenal and Long Bridge.	Number of cords of wood landed.	Number of tons of coal landed.	Number of tons of stone and ice.	Number of tons miscellaneous.
1860	7 feet.	15 feet.	5 steamers, 3 tugs	$120,000	60,000	7	806	31,000	13,000	....
1875	11 feet.	12 feet.	12 steamers, 17 tugs	825,000	400,000	23	18,000	120,000	77,000	177,000

In order to make a channel 200 feet wide and 12 feet deep at low-water below the draw of the Long Bridge, it will be necessary to dredge 262,000 cubic yards.

ESTIMATE.

262,000 cubic yards, at 20 cents per yard	$52,400
Contingencies, 10 per cent	5,240
Total	57,640

Money statement.

July 1, 1876, amount available	$9,441 87
July 1, 1877, amount expended during fiscal year	6,585 25
July 1, 1877, amount available	2,856 62
Amount (estimated) required for completion of existing project	100,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	100,000 00

G 2.

IMPROVEMENT OF ACCOTINK CREEK, VIRGINIA.

No funds have been available for this improvement, and no work has been done. The amount required to complete the work according to the original estimate is $14,000. The appropriation made June 10, 1872, was $5,000.

The following extracts from a letter of Mr. P. H. Troth, of Accotink, dated June 26, 1877, give the present state of trade:

The amount of trade from this place has been very light since July 1, 1876, owing to the channel, which is not of sufficient width and depth. About 3,000 cords of wood and 5,000 bushels of grain have been shipped from here since July 1, 1876. * * * The present condition of the channel is not very good. About 600 yards of it is 20 feet wide and 1½ feet deep at low-water; the balance will average 30 feet wide and 2½ feet deep.

Accotink is in the collection-district of Alexandria, which is the nearest port of entry.

G 3.

IMPROVEMENT OF OCCOQUAN RIVER, VIRGINIA.

No appropriation has been made for this work since that of March 3, 1875, which had been expended at the date of the last report. At that time the channel through the "lower mud," which had filled in, had been partially redredged. It is very necessary that this work should be completed. Owing to its unfinished condition and location, it is exposed to further deterioration, and it is estimated that $5,000 will be required for its completion. A further appropriation of $5,000 was recommended in the last report for the construction of a dike at the bar midway between the railroad bridge and the town of Occoquan, in order to preserve the depth of the dredged channel.

The original estimate for this work was $18,000, but this has been increased for the reasons stated in previous reports.

The following appropriations have been made:

March 3, 1873, $5,000.
June 23, 1874, $5,000.
March 3, 1875, $5,000.

Occoquan is in the collection-district of Alexandria.

Mr. J. T. Janney, of Occoquan, furnishes the following estimate of the trade in this river for the year ending July 15, 1877.

RECEIPTS.

26,893 bushels wheat, valued at	$35,980 04
770 bushels corn, valued at	471 31
Estimated amount of merchandise received by 7 stores	40,000 00
Total	76,451 35

SHIPMENTS.

5,090 barrels of flour, valued at	$30,540 00
13,586 bushels mill offal, valued at	2,140 32
30,806 pounds sumac, valued at	361 00
8,200 cords of wood, valued at	28,650 00
Wharf and bridge piles and lumber, value	11,160 00
400,000 hogshead hoops, value	14,500 00
133,000 barrel hoops, value	1,350 00
21,151 cedar posts, value	3,187 65
700 empty barrels, value	118 00
2,000 dozen eggs	250 00
	92,256 97

The improvement of the navigation through the "lower mud" was limited by the funds to the enlargement and deepening of the old channel. As this channel lies obliquely to the course of the ebb and flow of the tide, it does not preserve its depth as well as it would have done if it had been located in the course of the ebb-current. If the trade of the river is deemed of sufficient importance, a new cut should be made in conformity to the tidal current, and for this purpose $10,000 would be required.

Money statement.

July 1, 1876, amount available	$422 01
July 1, 1877, amount expended during fiscal year	220 00
July 1, 1877, amount available	202 01
Amount (estimated) required for completion of existing project	10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	10,000 00

G 4.

IMPROVEMENT OF AQUIA CREEK, VIRGINIA.

As there have been no funds available for this improvement during the year, no work has been done. The last contract was completed in September, 1875, a channel having been excavated between the railroad-bridge and the "Narrows," 40 feet wide, and 4 feet deep at low-water.

The estimate for the entire work as stated in the last report is $20,000.

The following appropriations have been made:

June 10, 1872, $1,500.
March 3, 1873, $2.000.
March 3, 1875, $2,000.
To complete the work $14,500 will be required.

This creek is in the collection-district of Alexandria. The trade is confined to occasional shipments of lumber, wood, and produce in light-draught vessels, no returns of which have been received.

Money statement.

Amount (estimated) required for completion of existing project	$14,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	14,500 00

G 5.

IMPROVEMENT OF NOMINI CREEK, VIRGINIA.

At the date of the last annual report the dredging under the contract with Messrs. J. H. Teemyer & Co. had not been completed. Operations were resumed August 16, 1876, and continued until September 5, when the funds were exhausted. The amount of material excavated during the period was 5,003 cubic yards, being, as heretofore, a mixture of sand and shells.

A survey of the channel was made upon its completion.

The channel was found generally in very good condition. That part of it through the bar at Hickory Point preserves its depth well, owing to the rapid tidal current passing through it, and the absence of cross-currents. The velocity is still too great for safe navigation, and further widening would improve the channel. The widening of the channel near White Point, which was intended to decrease the velocity of the direct and

cross currents, which made navigation dangerous, has proved successful, and has accomplished this result. The channel here has also preserved its depth. There is, however, a tendency to the deposit of sand on the point, owing to a change in the direction of the current. The channel between White Point and Nomini Bay has a direction across that of the tidal current passing to and from Currioman Bay, and it is also exposed to the full force of the northwest winds which prevail at some seasons. The fine sand of which the bottom is largely composed is thus swept into the channel. The filling has been to some extent removed each year by dredging, so that this action has not yet been sufficient to seriously impair the channel. In order to obviate its effects, the channel should be widened further. Owing to the exposed condition of this work and the causes referred to, the estimate of last year must be increased to $7,500, which amount would insure a comparatively permanent improvement.

The work already done has proved of great benefit to the section of country of which this stream is the natural outlet. A steamboat now makes semi-weekly trips between Nomini Ferry and Washington, passing through the channel. No statistics of trade have been received.

Nomini Creek is in the collection-district of Alexandria, which is the nearest port of entry.

Money statement.

July 1, 1876, amount available	$1,653 23
July 1, 1877, amount expended during fiscal year	1,653 23
Amount (estimated) required for completion of existing project	7,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	7,500 00

G 6.

IMPROVEMENT OF RAPPAHANNOCK RIVER, VIRGINIA.

The appropriation of $10,000 made by the river and harbor act approved August 14, 1876, was made available January 22, 1877. The work proposed was the continuation of the dredging operations at Fredericksburg Bar, and the construction of a dike below the steamboat wharf.

The following is an abstract of bids opened March 7, 1877, at 12 m.:

Number.	Name and address.	Dredging. Per cubic yard.	Dredging. Amount for 20,000 cubic yards.	Dike. Per linear foot.	Dike. Amount for 350 linear feet.	Total.	Time of— Commencement.	Time of— Completion.	Average daily work, cubic yards.	Number and kind of machines.
							1877.	1877.		
1	Thos. P. Morgan, Washington, D. C.	$0 28	$5,600 00	*4 90	$1,715 00	$7,315 00	Apr. 1	July 1	......	2 Osgoods.
2	Edwin H. French, Fulton, N. Y.	45	9,000 00	5 50	1,925 00	10,925 00	May 1	Sept. 1	600	1 Osgood.
3	G. H. Ferris, Brooklyn, N. Y.	29¼	5,950 00	4 75	1,662 50	7,612 50	May 15	Sept. 15	400	1 Osgood.
4	Clinton Stephens, New York City.	32	6,400 00	7 31	2,569 00	8,969 00	May 1	Dec. 1	......	....
5	Wm. H. Groat, Washington, D. C.	33	6,600 00	4 55	1,592 50	8,192 50	May 1	Aug. 1	500 to 3,000	Suitable mach'ry.
6	J. H. Fenner, Albany, N. Y.	48	9,600 00	10 00	3,500 00	13,100 00	Apr. 2	July 2	......	....

* Conditional upon acceptance of bid for dredging.

Contract awarded to Thomas P. Morgan, of Washington, D. C.

Work was commenced April 24. The dike was completed June 12; the dredging is still in progress, and will probably be completed in July. The channel is 50 feet wide and 9 feet deep at low-water; the material found is entirely sand, and is deposited behind the dikes along the river. The freshets bring down a constant supply of sand, and the dredging will need to be continued each year to preserve the depth required for navigation. For this purpose an appropriation of $7,500 will be required. At the close of the present work the dikes will all be filled so that for future dredging a new dike must be built, the cost of which will be $8,000. The deposit of material in the river at points below would be injurious to navigation, and as the lands adjacent to the river are used as farms, it could not be deposited on them, unless land were purchased for this purpose.

The estimate for improving the river below Fredericksburg is $44,000, as stated in Colonel Craighill's report for 1874. (Report of Chief of Engineers for 1874, Part II, p. 30.) Until more permanent results are secured at Fredericksburg, the execution of this work will hardly be advisable.

Statistics of trade have been requested, but none have been received.
The work is in the collection-district of Rappahannock.

Money statement.

July 1, 1876, amount available	$400 75	
Amount appropriated by act approved August 14, 1876	10,000 00	
		$10,400 75
July 1, 1877, amount expended during fiscal year	7,481 74	
July 1, 1877, outstanding liabilities	631 62	
		8,113 36
July 1, 1877, amount available		2,287 39
Amount (estimated) required for completion of existing project		59,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		15,500 00

G 7.

IMPROVEMENT OF ELIZABETH RIVER, VIRGINIA.

The continuation of the improvement of this river was provided for by an appropriation of $5,000 made in the act of August 14, 1876. The work was advertised for contract in the usual manner, and the following bids received and opened at 12 m. on June 20, 1877:

Number.	Name and address.	Park's Gap, excavation.		Park's Gap, dredging.		Near canal-lock, dredging cut-off.		Total.	Time of commencement.	Time of completion.
		Per cubic yard.	For 2,500 cubic yards.	Per cubic yard.	For 5,000 cubic yards.	Per cubic yard.	For 10,000 cubic yards.			
									1877.	1878.
1	Clint'n Stephens, Brooklyn, N. Y.	$0 40	$1,000	$0 40	$2,000	$0 40	$4,000	$7,000	July 15	Jan. 1
										1877.
2	G. H. Ferris, Baltimore, Md.	40	1,000	30	1,500	29½	2,950	5,450	Sept. 15	Dec. 1
3	Thos. P. Morgan, Washington, D. C	30	750	20	1,000	20	2,000	3,750	Aug. 1	Oct. 15
4	H. E. Culpepper, Portsmouth, Va.	28	700	25	1,250	30	3,000	4,950	July 10	Nov. 30

Contract awarded to Thomas P. Morgan, of Washington, D. C.

The work proposed is widening Park's Gap and its approaches, and the excavation of a cut-off near the lock of the Albemarle and Chesapeake Canal in order to facilitate the passage of vessels into the lock.

Owing to the increased traffic passing through this river, a more extended system of improvement than was at first contemplated has been found necessary. The depth has been increased from 5 to 7½ feet, and the navigation much improved.

Several small bars have formed below Park's Gap, for the removal of which an appropriation of $5,000 is recommended.

The original estimate for this improvement was $25,000.

Appropriations have been made as follows:

March 3, 1873, $15,000.
June 23, 1874, $10,000.
March 3, 1875, $5,000.
August 14, 1876, $5,000.

Elizabeth River is in the collection-district of Norfolk, Va., at which the custom-receipts for the year ending June 30, 1876, were $23,482.90.

The increase of trade in this river is shown by the following statement of the number of passages through the Albemarle and Chesapeake Canal since 1870. The number includes all classes of vessels.

Year ending September 30, 1870	4,382
Year ending September 30, 1871	4,900
Year ending September 30, 1872	4,808
Year ending September 30, 1873	5,770
Year ending September 30, 1874	6,283
Year ending September 30, 1875	6,502

The shipments north during the year 1875 included 47,754 bales cotton, 13,217 barrels fish, 11,202 barrels naval stores, 440,907 bushels corn, 32,619 railroad ties, 46,475 bushels potatoes, 27 million feet of lumber, 31 million shingles.

Money statement.

July 1, 1876, amount available	$118 02
Amount appropriated by act approved August 14, 1876	5,000 00
	5,118 02
July 1, 1877, amount expended during fiscal year	128 13
July 1, 1877, amount available	4,989 89
Amount (estimated) required for completion of existing project	5,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	5,000 00

G 8.

IMPROVEMENT OF NORFOLK HARBOR, VIRGINIA.

In the act approved August 14, 1876, an appropriation of $35,000 was made for the improvement of this harbor. The work was advertised in the usual manner and the following bids were received and opened on June 20 at 12 m.:

Number.	Name and address.	Dredging, per cubic yard.	Time of— Commencement.	Time of— Completion.	Average daily work, cubic yards.	Number and kind of machines.
1	Morris & Cumings Dredging Company, New York City.	$0 13	Oct. 1, 1877	Dec. 30, 1877		
2	E. R. Seward, Albany, N. Y.	16	July 15, 1877	Dec. 30, 1877	2,000	1 clam-shell, or 2 dippers.
3	Clinton Stephens, Brooklyn, N. Y.	24	July 10, 1877	July 10, 1878		
4	Morris F. Brainard, Albany, N. Y.	11½	Sept. 1, 1877	Feb. 15, 1878	800 to 1,200	1 or more Starbuck or 1 clam-shell.
5	Sidney F. Shelbourne, New London, Conn.	9½	Sept. 15, 1877	June 30, 1878	1,500 to 2,000	1 clam-shell.
6	American Dredging Company, Philadelphia, Pa.	20	July 16, 1877	Oct. 16, 1877	....	Grapple-dredge.
7	A. J. Dalton, Norfolk, Va.	36	Aug. 16, 1877	Jan. 1, 1878	700	3 dredges.
8	H. E. Culpepper, Portsmouth, Va.	18	July 16, 1877	Feb. 16, 1878		
9	J. H. Fenner, Albany, N. Y.	17	July 15, 1877	July 1, 1878	700 to 800	2 or more dippers.
10	G. H. Ferris, Baltimore, Md	10¾	July 20, 1877	June 30, 1878	800	1 large dipper.
11	Austin P. Brown, Washington, D. C.	18¾	6 weeks after execution of contract.	In 8 months.		

The contract was awarded to Mr. Sidney F. Shelbourne, of New London, Conn., who was informed of the fact on the last day of the fiscal year.

It will be seen from an examination of the bids that the lowest and next to the lowest bids are much less than might have been anticipated, on account of the distance and exposed position of the dumping-ground. A large amount of work can be done under the present contract, and, assuming that the same rates will be offered at the next letting, the amount required to complete the work will be less than the original estimate. Upon this assumption, $25,000 will be sufficient to complete the dredging at the mouth of the eastern branch of Elizabeth River and to remove any wrecks which are likely to cause objectionable deposits.

In my report of February 15, 1875, the changes which had taken place in the harbor of Norfolk and its approaches were referred to, and a survey was recommended to determine the amount of deterioration and to obtain data for the establishment of port-warden lines. This work has been partly executed by a board of officers appointed at the request of the harbor commissioners. The board have recommended the establishment of port-warden lines, and have submitted a general plan for the improvement of the harbor and its approaches, so as to give a depth of 25 feet at low-water as far as the navy-yard.

The dredging recommended by the board in the harbor of Norfolk, exclusive of the approaches, was as follows:

	Cubic yards.
1. On the border of Portsmouth Flats	550,000
2. At the mouth of the Eastern Branch	250,000
3. Between the mouth of the Southern Branch and Berkeley Flats	130,000
Total	930,000

I would state that the second item of the above estimate includes my estimate for the improvement of the harbor, made in the report of February 15, 1875, and the appropriation of August 14, 1876, was for the purpose of executing this work.

In order to carry 25 feet from Hampton Roads up to the city of Norfolk, it will be necessary to dredge the channel between the Hospital light and Sewall's Point, so as to give a width of 400 feet and a low-water depth of 25 feet, which will require the removal of about 1,200,000 cubic yards of material.

As the final recommendations of the board have not yet been made public, it seems proper to defer for the present making any estimate for the general improvement of the harbor and its approaches.

Norfolk is a port of entry. The receipts of customs for the year ending June 30, 1876, were $26,482.90. The business of the city is, however, almost entirely confined to exports and domestic shipments of cotton, naval stores, lumber, breadstuffs, &c.

The following statistics of the trade and shipping are given, in addition to those presented in the report of February 15, 1875:

Foreign-bound clearances.

Year.	No. of bottoms.	Tonnage.
1873	71	30,613
1874	96	51,139
1875	119	53,683
1876	94	65,504
Total	380	200,939

Coastwise clearances.

Year.	Tonnage.	Crew.	No. of bottoms.
1873	1,021,376	29,368	1,072
1874	1,119,029	30,506	1,163
1875	968,271	25,865	1,032
1876	1,104,747	28,800	1,078
Total	4,213,423	114,539	4,349

STATEMENT OF EXPORT VALUES.

1873	$1,267,769
1874	3,906,318
1875	6,243,972
1876	7,825,112
Total	19,243,171

Money statement.

Amount appropriated by act approved August 14, 1876	$35,000 00
July 1, 1877, amount expended during fiscal year	289 15
July 1, 1877, amount available	34,710 85
Amount (estimated) required for completion of existing project	25,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	25,000 00

G 9.

IMPROVEMENT OF NANSEMOND RIVER, VIRGINIA.

The appropriation of $5,000 for the improvement of this river was made available May 1, 1877, and the work duly advertised for contract. The following bids were received and opened June 20, 1877, at 12 m:

No.	Name and address.	Dredging. Per cubic yard.	Dredging. For 10,000 cubic yards.	Repairing dike. Per section.	Repairing dike. For 150 sections.	Total.	Time of commencement—	Time of completion—
							1877.	1877.
1	H. E. Culpepper, Portsmouth, Va.	$0 30	$3,000	$16 50	$2,475	$5,475	July 15	Nov. 15
2	G. H. Ferris, Baltimore, Md.	12½	1,250	21 00	3,150	4,400	Aug. 15	Dec. 1
3	Morris & Cumings Dredging Company, New York City.	20	2,000	20 00	3,000	5,000	Oct. 1	Dec. 31

Contract awarded to G. H. Ferris, of Baltimore, Md.

The work proposed is the widening of the channel at Suffolk and dredging a channel through a bar below Shingle Creek, and also repairing the old dike at Western Branch Bar.

The original estimate for improving this river was $30,000.

The following appropriations have been made:

March 3, 1873, $15,000.
June 23, 1874, $10,000.
March 3, 1875, $5,000.
August 14, 1876, $5,000.

As stated in the last report, $2,000 will be required for the completion of the work.

The following is an estimate of the trade for the year ending June 30, 1877:

SHIPMENTS.

Twenty thousand cords wood, 3,000,000 feet of lumber, 100,000 water-melons, 80,000 bushels wheat, 100,000 bushels corn, 200,000 railroad-ties, 1,000 barrels citrons, 20,000 tons of hay, 40,000 bushels lime, 5,000 barrels potatoes, together with a large amount of fruit.

The receipts include coal, ice, &c.

Suffolk is in the collection-district of Norfolk, the receipts of which, during the year ending June 30, 1876, were $26,482.90.

Money statement.

July 1, 1876, amount available	$87 59	
Amount appropriated by act approved August 14, 1876	5,000 00	
		5,087 59
July 1, 1877, amount expended during fiscal year		347 07
July 1, 1877, amount available		4,740 52
Amount (estimated) required for completion of existing project		2,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		2,000 00

G 10.

IMPROVEMENT OF PAMPLICO RIVER, NORTH CAROLINA.

The improvement proposed in the report of an examination of this river dated December 14, 1875, consisted in dredging a channel through the bar near the town of Washington and at other points in the river-channel, and in removing the pile-obstructions near Hill's Point, about 6 miles below Washington. For this work an appropriation of $15,000 was made by the act of August 14, 1876, and became available for the same May 1, 1877.

The work was advertised for contract and the following bids received and opened at 12 m. on June 27, 1877:

Separate bids were invited for dredging and removing piles.

Number.	Name and address.	Dredging, per cubic yard.	Removing piles, each.	Time of— Commencement.	Completion.
1	George C. Forbes, Baltimore, Md	$0 29*	$4 70*	Aug. 1, 1877	Jan. 1, 1878
2	G. H. Ferris, Baltimore, Md	15	3 00	Oct. 1, 1877	July 1, 1878
3	Clements Brown, Norfolk, Va	....	4 00	July 15, 1877	Nov. 15, 1877
4	Swindell & Sparrow, Washington, N. C	....	1 90	Aug. 1, 1877	Nov. 10, 1877
5	Clinton & Stephens, Brooklyn, N. Y	30	3 00	July 10, 1877	Jan. 1, 1878
6	J. H. Fenner, Albany, N. Y	21	2 00	Sept. 1, 1877	Jan. 1, 1878
7	Thomas P. Morgan, Washington, D. C	20	2 00	Sept. 15, 1877	April 1, 1878
8	Morris F. Brainard, Albany, N. Y	21¼	1 40*	July 15, 1877	Oct. 10, 1877
9	William Flannery, New York City	15	3 75	July 30, 1877	Nov. 30, 1877
10	H. E. Culpepper, Portsmouth, Va	25	3 00	Sept. 1, 1877	Feb. 1, 1878

* Conditional upon award of whole work.

Contract for dredging awarded to G. H. Ferris, of Baltimore, Md.
Contract for removing piles awarded to Swindell & Sparrow, Washington, N. C.

The prices at which this work has been let are much lower than those of the original estimate made when much higher ones prevailed. It will be practicable to do all the work then contemplated under the present appropriation, and no further appropriation will be required.

Money statement.

Amount appropriated by act approved August 14, 1876	$15,000 00
July 1, 1877, amount expended during fiscal year	363 96
July 1, 1877, amount available	14,636 04

G 11.

IMPROVEMENT OF ROANOKE RIVER, NORTH CAROLINA.

At the commencement of the fiscal year the work upon the dike at Indian Highland Bar was suspended on account of the sickness of the superintendent and his men. The contractor seemed to be unable to find a competent man to conduct his operations.

The driving of the sheet-piling was resumed about July 15, but the work still advanced slowly, sometimes on account of high-water, sometimes from breaking of machinery, and sometimes for the want of an engineer and superintendent. The contractor was urged to send

competent men to conduct the work. He assigned as a reason for not doing so the difficulty of inducing any one to remain in so sickly a locality. In the midst of these delays the river rose rapidly when the work was in an exposed condition, and all operations were necessarily suspended. The high-water continued from August until December, when the work was examined and was found to have been considerably damaged. As the funds were insufficient for the repairs, further operations were suspended. The contractor, although he had been dilatory, had been delayed by the illness of his superintendent, and his operations had been further obstructed by the sudden floods, which were unusually frequent.

It has been previously stated that one of the obstacles to improving the Roanoke is the sudden change in the water-level, and another obstacle, even more formidable, is found in the shifting of the sand-bars. The bars, however, are generally passable at the time when the crops are being forwarded to market, and navigation is supended when the business of transportation has almost ceased. It does not appear that the present state of trade demands an immediate improvement of the river. Some snags might be removed with advantage. Before this can be done it will be necessary to build new snag-boats, as the old ones are so much decayed that they cannot be used another season.

To build new boats with suitable machinery will cost	$2,000 00
For removing snags there will be required	2,000 00
Total	4,000 00

A full account of the obstructions and the difficulties of improving the river will be found in my reports for 1875 and 1876.

The estimate for the improvement of the entire river is $222,000, of which at least $45,000 should be appropriated for the first year if the entire work is to be undertaken. This project, however, is left for the approval of Congress.

The following appropriations have been made:

March 3, 1871, $20,000.
June 10, 1872, $10,000.
March 3, 1873, $10,000.
June 23, 1874, $5,000.
The nearest collection-district is Edenton, N. C.

Money statement.

July 1, 1876, amount available	$5,282 63
July 1, 1877, amount expended during fiscal year	5,100 65
July 1, 1877, amount available	181 98
Amount (estimated) required for completion of existing project	222,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	4,000 00

G 12.

IMPROVEMENT OF PERQUIMAN'S RIVER, NORTH CAROLINA.

An appropriation of $2,500 was made August 14, 1876, for the removal of stumps, logs, &c., obstructing the channel of this river at Hertford, and became available for the work May 1. Suitable snag-boats and machinery had previously been in use on the Roanoke River,

and it was recommended that these be transferred to Perquiman's River and that the work be done by hired labor, it being evident that the work could be done in this way more cheaply than by contract. This recommendation having been approved, the snag-boats were repaired at Plymouth, where they had been laid up, and towed to Perquiman's River in June, 1877. The work of removing the stumps with the aid of giant-powder is now in active progress. It is not probable that any further appropriation will be needed for this work.

Money statement.

Amount appropriated by act approved August 14, 1876	$2,500 00
July 1, 1877, amount expended during fiscal year	345 86
July 1, 1877, amount available	2,154 14

G 13.

IMPROVEMENT OF FRENCH BROAD RIVER, NORTH CAROLINA.

An appropriation of $10,000 was made in the act approved August 14, 1876, for the improvement of this river between Brevard and the Buncombe-County line, and became available May 1, 1877. Examinations of the river were made under the direction of Major McFarland, Corps of Engineers, in 1874–'75, who submitted an approximate estimate for the improvement of the river, based upon levels carefully deduced from railroad surveys. By this examination the project of improving the river by means of lateral dams, dredging, and excavation, so as to give 30 inches over the bars at low-water, was found to be impracticable.

No instrumental survey of the river had ever been made or maps prepared, without which a definite project and estimate for its improvement could not be submitted, or even the practicability of such improvement determined upon. Arrangements have been made for this survey, and it will be begun in July. The appropriation provides for the improvement of the upper section of the river, making no provision for the lower section, between the Buncombe-County line and Asheville, which is even more difficult of navigation, but which is an essential part of an efficient improvement.

Money statement.

Amount appropriated by act approved August 14, 1876	$10,000 00
July 1, 1877, amount available	10,000 00

APPENDIX H.

ANNUAL REPORT OF LIEUTENANT-COLONEL Q. A. GILLMORE, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1877.

UNITED STATES ENGINEER OFFICE,
New York, July 13, 1877.

GENERAL: I have the honor to submit herewith the annual reports for the fiscal year ending June 30, 1877, upon the works of river and harbor improvement under my charge.

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Lieut. Col. of Engineers, Bvt. Maj. Gen., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

H 1.

IMPROVING CHARLESTON HARBOR, SOUTH CAROLINA.

During the fiscal year ending June 30, 1877, the work in Charleston Harbor was confined to the lowering of the channel end of the Bowman jetty to mean low-water on the outer portion and to 2 feet above that level on a portion adjacent thereto. A little dredging was done in the Beach Channel by the United States dredging-steamer Henry Burden.

The following communication from Capt. James C. Post, Corps of Engineers, gives a report of these operations in sufficient detail:

SAVANNAH, GA., *June* 30, 1877.

COLONEL: I have to submit the following report of the work for the improvement of Charleston Harbor, S. C., conducted during the past fiscal year ending June 30, 1877. The operations for the past year have been confined to the improvement of Beach Channel entrance to this harbor. In October, the dredging-steamer Henry Burden having been transferred to this channel, the dredging was commenced. After the removal of 680 cubic yards of material this was suspended, as the shoaling that had taken place near the western entrance to the channel had been so great that there was not sufficient water for the steamer to work in. At this time there was but 10.5 feet through this portion at high-water, or 5.1 feet at mean low-water.

Shortly after this it was determined to lower 135 feet of the Bowman jetty to low-water. This work was commenced in October, 1876, and was completed in January. Soundings taken after its completion gave 13.5 feet as the least depth in the channel.

During this work the prevailing winds were westerly. This result was so favorable that it was thought best to extend this lowering over an additional distance of 50 feet. At the completion of this, soundings gave, as the least depth, 12.5 feet, or a shoaling of 1 foot in depth. The prevailing winds during this portion of the work were easterly. Notwithstanding this, it was decided to continue the lowering, and it has been done up to the present time. In all, 185 feet have been lowered to low-water and 205 feet to 2 feet above low-water. In doing this 4,800 cubic yards of stone have been removed.

During the lowering of the latter portion the prevailing winds have been easterly until within the last ten days, since which time they have been westerly. Soundings taken during the progress of lowering this portion gave no improvement in depth before the commencement of the westerly winds. On June 25, soundings were again taken. These last show decided improvement, 14 feet being the least water found in any of the lines upon which soundings were taken.

From the above it will be seen that the whole of the improvement has taken place during the prevalence of the westerly winds. The direction of Beach Channel is nearly east and west, and the natural effect of these winds, especially those from the southwest, is to drive more water through Beach Channel on the ebb-tide as the jetty is lowered. It is due to this, in my opinion, that the greater depth has been obtained. The ebb-current from the Hog Island Channel and the basin in the rear of Sullivan's Island passes along the western end of the latter island, and following the trend of the shore flows along the south side of the island until it meets the Bowman jetty, which, while it was at its former height, deflected the greater portion through the Swash Channel. Since the lowering of the jetty a larger proportion of it escapes over the jetty and through the Beach channel, a still greater proportion being driven through it during the westerly winds. This is made still clearer when it is considered that the depth gained during the lowering of the first 135 feet was assisted by the westerly winds, and that during the lowering of the remaining 255 feet while the easterly winds were prevailing, not only no increase of depth was gained, but the depth was actually lessened 1 foot. A return of the westerly winds has now given an increase of 1.5 feet in depth.

I believe, therefore, that as the work of lowering progresses it tends rather to an equalization of the volumes of water passing through this channel on the ebb and flood tides, and that it is this effect that gives the increased depth in this channel.

Very respectfully, your obedient servant,

JAMES C. POST,
Captain of Engineers.

Lieut. Col. Q. A. GILLMORE,
Corps of Engineers, U. S. A.

It was thought best to postpone the resumption of dredging in Beach Channel until the beneficial effects produced upon the regimen of the channel by lowering the Bowman jetty had reached a maximum, and had been carefully observed and studied. The work upon the jetty has been necessarily slow, for the reason that but few men can work there to advantage, and only about three to four hours per day on an average, under the most favorable circumstances, so that useful results are greatly retarded.

The money expended upon the jetty during the last fiscal year was not intended for that purpose when the estimate was submitted. It was originally contemplated to expend the entire sum in dredging in Beach Channel, but the unlooked-for shoaling of that channel to a depth less by several feet than has ever been known to exist there for many years, led to the conclusion that no improvement secured by dredging alone could be expected to be permanent. The lowering of the outer end of the jetty, by which the sectional area of the water-way and the volume of flow have been increased, has had the desired effect, and it is hoped that the balance on hand will suffice for such dredging as may be deemed necessary.

The work upon the jetty has been suspended in order to ascertain to what extent results of a permanently beneficial character have been secured.

To provide for such additional work upon the jetty as shall be found to be necessary—either in shortening or in still further lowering it—a small appropriation of $5,000 is recommended.

The original project for the improvement of the Ship Channel in Charleston Harbor, submitted May 13, 1871, estimated the total cost at $73,700 to $75,700. It contemplated the removal of nine wrecks, or parts of wrecks, in different parts of the harbor, and the removal of 125 linear feet from the outer end of Bowman jetty. It has been found

that the amount of stone necessary to be removed from the jetty has exceeded that provided for in the original estimate by several thousand yards. The width of the jetty at the bottom was concealed by the sand which covered it to a considerable depth, and its real extent could not be ascertained, although carefully examined by submarine divers. It was found to have spread out by undermining and settlement greatly beyond its dimensions as first designed.

A table of commercial statistics of the port and showing the amount of revenue collected in each of the past four years, furnished by the collector at Charleston, is appended hereunto.

The amounts and dates of all former appropriations for this work are as follows:

By act approved March 3, 1871	$13,000
By act approved June 10, 1872	38,700
By act approved March 3, 1873	5,000
By act approved June 23, 1874	18,000
By act approved March 3, 1875	10,000
By act approved August 14, 1876	10,000
Total	94,700

Of this amount there had been expended up to the close of the last fiscal year (including outstanding liabilities) $88,637.93.

Money statement.

July 1, 1876, amount available	$1,008 80	
Amount appropriated by act approved August 14, 1876	10,000 00	
		$11,008 80
July 1, 1877, amount expended during fiscal year	3,640 09	
July 1, 1877, outstanding liabilities	1,306 64	
		4,946 73
July 1, 1877, amount available		6,062 07
Amount (estimated) required for completion of existing project		11,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		5,000 00

Entrances and clearances of vessels at the custom-house, port of Charleston, South Carolina, from 1873 to 1876, inclusive.

VESSELS ENTERED.

Year.	Coastwise.			American vessels from foreign ports.			Foreign vessels from foreign ports.			Total.		
	Number of vessels.*	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.
1873	463	349, 602	10, 245	57	13, 067	414	80	34, 973	1, 015	600	397, 642	11, 674
1874	510	372, 378	11, 467	45	11, 484	355	174	77, 940	2, 198	729	461, 802	14, 020
1875	504	382, 018	11, 649	38	13, 144	326	198	88, 879	2, 404	740	484, 041	14, 379
1876	471	340, 439	10, 113	44	11, 898	335	224	101, 272	2, 768	739	453, 609	13, 216

VESSELS CLEARED.

Year.	Coastwise.			American vessels for foreign ports.			Foreign vessels for foreign ports.			Total.		
	Number of vessels.*	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.
1873	400	290 950	9, 189	56	17, 678	481	97	47, 822	1, 250	553	356, 450	10, 920
1874	409	318, 619	10, 148	52	18, 236	473	192	84, 205	2, 335	653	421, 060	12, 956
1875	461	328, 266	10, 830	57	24, 679	555	211	94, 595	2, 527	729	447, 540	13, 912
1876	431	278, 744	9, 095	60	23, 598	546	230	103, 276	2, 812	721	405, 618	12, 453

Year.	Value of exports.	Value of imports.	Import duties collected.
1873	$14, 350, 041	$746, 139	$152, 759
1874	17, 900, 146	803, 573	164, 107
1875	19, 655, 966	680, 343	80, 656
1876	18, 088, 152	455, 562	89, 168

*The above only exhibits the number of vessels in the *coastwise trade* that are required by law to enter and clear at the custom-house. A large number of vessels arrive and depart which are not required to so enter and clear.

H 2.

IMPROVING SAVANNAH RIVER AND HARBOR, GEORGIA.

The work that has been accomplished during the past fiscal year, toward the improvement of the river and harbor of Savannah, is reported by Capt. James C. Post, United States Corps of Engineers, assistant on the work, under date June 30, 1877, as follows:

The following are the places at which operations have been conducted during the past year:

1. The Cross Tides Dam.
2. The channel between King's and Hutchinson's Islands.
3. The new channel at "The Wrecks."
4. The shoal southwest of Oyster Bed light and northwest of Fort Pulaski.
5. The channel northeast of Fort Pulaski.

The temporary injunction granted by the Supreme Court of the United States, restraining the completion of the dam at the Cross-Tides having been removed, work was resumed upon it March 6, 1877. This was continued until April 22, when a freshet, bringing with it a large quantity of drift material, destroyed 186 feet of its outer end. The greater portion of this was only partially constructed. After the displaced material had been removed and a sufficient amount of sheet-piling had been driven to properly secure the southern extremity of the dam with the shore, work was suspended until further consideration could be given to the modification of the present plan of construction, which modification is now deemed necessary. A detailed report of this work is inclosed herewith.

To further aid the ebb-flow into Front River, and also to relieve the pressure upon the dam during its construction, the water-way between King's and Hutchinson's Islands has been increased to 60 feet in width and 9 feet in depth at low-water, by the removal of 25,047 cubic yards of material. This was done under a contract made with the city of Savannah, whose proposal to remove with their dredge 50,000 cubic yards for 24 cents per cubic yard, was accepted March 24, 1877.

At the new channel at "The Wrecks" 115,189 cubic yards of material have been removed, and one crib taken out from its south side, 57,501 cubic yards of this material have been removed by the United States dredging-steamer Henry Burden, 2,713 cubic yards by the city of Savannah, and, under a contract for the removal of 100,000 cubic yards, 54,975 cubic yards by the American Dredging Company.

One cut 5,879 feet in length, 24 feet wide, and 15 feet deep, mean low-water, has been made through the entire length of this shoal. The flowing in from the sides has reduced this depth to 12 feet mean low-water, while at the same time its width has been increased to 60 feet by this flowing in, together with the scour of the increased current. A second cut of the same dimensions as the first is now being made by the American Dredging Company. They have opened it to a distance of 2,879 feet from the western end of the shoal. A third cut is also being made by the dredge of the city of Savannah. They have progressed 451 feet.

There is now a channel-way through this shoal 250 feet wide between the 8-foot curves. Under the existing contracts with the American Dredging Company and the city of Savannah it is expected that a channel 120 feet wide and 13 feet deep, mean low-water, will be obtained by the commencement of the cotton-shipping season. The increase of the shoal southwest of Oyster Bed light and northwest of Fort Pulaski, and the consequent narrowing of the channel, rendered dredging necessary at this point. On May 2 the dredging-steamer Henry Burden commenced work upon this shoal and removed 12,012 cubic yards. By this removal the channel at the northwest end of the shoal was increased 400 feet in width at the 13-foot curves. Owing to the presence of a wreck or some sunken obstruction, probably a portion of one of the wrecks mentioned in the annual report of 1874 as removed, and which several times fouled the drag of the dredge, the channel was not increased in width between these curves at the southeast end of the shoal. Over this portion the water-way was deepened about 1 foot, which depth seems to be about on a level with the top of the wreck. After the removal of this wreck it is estimated that the channel between the 13-foot curves can be increased 150 feet in width by the removal of 2,400 cubic yards. It is due, undoubtedly, to this wreck that the shoal has been increasing.

The shoaling of the channel northeast of Fort Pulaski, as mentioned in the last annual report, having continued until the least depth in this channel was 12 feet 6 inches mean low-water, the dredging-steamer Henry Burden was, on June 11, in accordance with authority received, transferred to this channel. Since this time, 6,395 cubic yards have been removed and the channel is deepened to 12¾ feet. This shoaling is believed to have been caused by the contraction of the channel-way southeast of Oyster Bed light.

The other channels which have been dredged during previous fiscal years were sounded out during the present month with the following results, viz: At Garden Bank considerable shoaling has taken place in the channel. It is now 120 feet wide and 13 feet deep, mean low-water, at its narrowest part. The upper or western end of this shoal has, for a distance of 150 feet, been reduced materially. This is probably due to the opening of the new "Wrecks" channel, which allows an easier exit for the ebb-current passing down Front River. The wearing away of this shoal will probably be increased, now that an enlarged channel-way has been opened between King's and Hutchinson's Islands.

At the head of Elba Island, the lower half of the dredged channel has deepened. The upper half, especially at its junction with the south channel, has shoaled until now there is but 11½ feet mean low-water through it.

Abreast of Elba Island the greater portion of the channel has deepened, but near the lower end it has shoaled for a distance of 200 feet to 11½ feet mean low-water.

Opposite the lower end of Elba Island, the channel has shoaled to 10 feet mean low water for a depth of 400 feet. The other channel, where dredging is contemplated in the approved project, but has not yet been done, viz, opposite the upper end of Long Island, was also sounded. This channel, mentioned in the report for the fiscal year 1874 as having been deepened by scour, is now of the same depth as given on the Coast Survey chart of 1867, viz, 12½ feet.

The injury to the dam, referred to by Captain Post, was reported to the Chief of Engineers May 14, 1877, in the following letter:

NEW YORK, *May* 14, 1877.

GENERAL: I have the honor to transmit herewith a letter from my assistant, Capt. James C. Post, Corps of Engineers, dated Savannah, Ga., April 24, 1877, reporting serious damage to the temporary dam now in process of construction at the Cross-Tides, by drift-wood brought down by a heavy freshet, which occurred on and after April 20.

It appears from the report that the work first gave way in that portion which was begun prior to the suspension of operations on May 13, 1876, under an injunction from the United States Supreme Court. When work was resumed early last winter, it was found that some of the panels had been cut under and others carried away or broken, but it was thought that the strength of the piling was not seriously impaired, although they had been more or less shaken and otherwise disturbed in consequence of the weak and unprotected condition in which the work had been left through several months.

The recent damage is of such a character, and has left the portion which stands, although apparently uninjured, in such a state of possible weakness, that I do not deem it prudent to finish the dam at present in accordance with the original design. It is, moreover, very desirable, when the dam is being finished, and an increased flow is thereby secured in Front River, that funds should be available for widening at once the contracted water-way at Kinzey's Point, opposite the upper end of Savannah City, so as to prevent any possible damage to the city wharves.

The necessity for continuing the dredging in the new channel at the "Wrecks," in order to provide a practicable ship-channel there at the earliest moment, as the old "Wrecks" Channel is gradually filling up, has rendered it impossible to use any of the existing appropriation for work on Kinzey's Point.

I have, therefore, thought it best, all things considered, to direct a suspension of work on the dam until more money is appropriated.

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Lieut. Colonel of Engineers, Bvt. Maj Gen., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers.

LETTER OF CAPTAIN JAMES C. POST, CORPS OF ENGINEERS.

SAVANNAH, GA., *April* 24, 1877.

GENERAL: I have to report that from the 62d pile outward the Cross-Tides Dam has been destroyed by the freshet that has existed in the Savannah River since Friday, the 20th instant. At the 62d pile the water was 14 feet 8 inches deep at extreme low-water, and deepened to 22 feet at the 80th pile. This extreme low-water was 4 feet 4 inches below the cross-braces.

Apparently the dam first gave way between the 62d and 72d piles, all of the included ones being those driven under the contract made with Mr. Symons during the past year. Mr. Daubeney reported that all piles were driven from 12 to 17 feet in the bottom, but as he did not state the soundings at each pile when they were driven, I

have no means of knowing how far they were still in the bottom when the work was resumed this year. These piles, however, I examined thoroughly when Mr. Brown began, and they appeared to be strong and firm. The shutters between them had been driven by Mr. Brown to a depth of from 4 feet to 4½ feet.

For the past ten days, owing to the great rain-fall in the country drained by the Savannah early in the month, the water has been very high, and at its lowest stages falling only to the bottom of the cross-braces, and at its highest rising 4 feet 6 inches above them. On Thursday, the 19th instant, the water began to show considerable diminution in height, as though the freshet was abating, and up to this time the dam had not been apparently damaged. The next day another rise began, and with this came great quantities of drift material, and it is due to this latter entirely, in my opinion, that the dam was affected. Two men were engaged all day Saturday and Sunday, and Sunday night as well, in endeavoring to keep the dam free from this accumulation, which consisted of branches and trunks of trees, reeds, cane-brakes, and water-logged sticks and stumps, but the current was so strong and the accumulation so rapid, that it was found impossible to keep it clear; and in some places the openings between the piles were closed entirely from nearly the river bottom to above the cross-braces, the only escape for the water being on either side of the accumulation or under it. The current ran nearly 3 miles an hour, and without the drift material caused a pressure in the deepest water of 195 pounds to the running foot, which the dam appeared to stand successfully. Computing the panel as entirely closed, as above stated, this pressure is increased to 231 pounds per foot, or 1,380 pounds per panel. Even with this pressure, I believe the dam would have remained intact had it not been for the hydrostatic pressure exerted by the water in endeavoring to escape underneath the accumulation of drift, which drew the piles out of the river bottom and raised the whole structure, from the point mentioned outward, or a distance of 150 feet, from 1 foot to 3 feet, the depth at the same time being increased by the undercut of the current. At present, as the water is still very high and the current swift, I am unable to state the amount of damage done, if any, to the remaining portion of the dam. I have directed an examination to be made as soon as the water will permit it, when I will forward an additional report.

Very respectfully, your obedient servant,

JAS. C. POST,
Captain of Engineers.

Lieut. Col. Q. A. GILLMORE,
Corps of Engineers, U. S. A.

A detailed report of the dam will be submitted as soon as a project for its modification has been prepared.

Although such high freshets, accompanied by large bodies of driftwood, as caused the injury to the temporary work of the dam above referred to, are not of frequent occurrence on the Savannah River, it is believed that prudence requires some modification of the original design of the dam. Whether additional strength shall be given to it to a degree that will enable it to withstand any unusually great pressure to which it may be subjected in times of exceptionally high freshets, or whether it shall be entirely submerged so that it will be practically unaffected by freshets and drift materials, remains to be yet determined.

Although the unexpended balance of the appropriation is deemed to be quite sufficient for its completion upon either of the two plans above indicated, it is believed to be inexpedient to resume work upon it until the funds are provided for enlarging the water-way below the Cross-Tides, and especially at Kinzey's Point, so as to afford a free passage for the increased volume of water which the dam is expected to divert into Front River.

WORK RECOMMENDED FOR NEXT FISCAL YEAR.

It is proposed during the next fiscal year, in case of an appropriation being made, to continue the improvement of Savannah River, as indicated below.

1. To complete the dam at Cross-Tides.
2. To remove 150 to 200 feet from the outer end of the old King's Island jetty.

3. To increase the sectional area of the water-way in Front River, below the Cross-Tides, so as to provide a free flow of the enlarged volume of water which is expected to result from the completion of the dam. The points at which enlargement will be necessary are Kinzey's Point, opposite the city, and perhaps also the shallow channel between Marsh and Hutchinson's Islands.

4. To continue the dredging in the new channel at the "wrecks" to a mean low-water depth of 14½ feet and to a suitable width.

5. To remove the wreck or portion of wreck opposite the Oyster Bed light, and do such dredging as may be found necessary or desirable at that point.

6. To restore the depth of 14½ feet originally obtained in the channel northeast of Fort Pulaski, should it be found that no scour is induced in this channel as the result of removing the obstruction above it, opposite Oyster Bed light.

7. To dredge in other channels where shoaling has or may take place, should it become necessary to do so.

This work of improvement is located in the custom-district of Savannah.

A table of commercial statistics furnished by the collector of the port, showing the number, tonnage, and crews of vessels engaged in the foreign and coastwise trade, the value of exports, and the amount of import duties collected in each of the years 1873 to 1876, inclusive, is appended hereunto.

The estimated cost of the contemplated improvements of the Savannah River, submitted August 28, 1873, not including the cost of the necessary bulkheads along the amended water-way and jetties, and bulkheads elsewhere, is $481,320.

The amounts and dates of the appropriations made since the adoption of the present project are as follows:

By act approved June 23, 1874	$50,000 00
By act approved March 3, 1875	70,000 00
By act approved August 14, 1876	62,000 00
Total	182,000 00

Of this amount there had been expended up to the close of the last fiscal year (including outstanding liabilities) $154,147.85.

Money statement.

July 1, 1876, amount available	$3,771 81	
Amount appropriated by act approved August 14, 1876	62,000 00	
		$65,771 81
July 1, 1877, amount expended during fiscal year	28,634 49	
July 1, 1877, outstanding liabilities	9,285 17	
		37,919 66
July 1, 1877, amount available		27,852 15
Amount (estimated) required for completion of existing project		299,320 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		150,000 00

Entrances and clearances of vessels at the custom-house, port of Savannah, Ga., from 1873 to 1876, inclusive.

VESSELS ENTERED.

Year.	Coastwise.			American vessels from foreign ports.			Foreign vessels from foreign ports.			Total.		
	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.
1873	463	381, 595	11, 934	34	16, 140	383	213	119, 316	2, 999	710	537, 056	15, 316
1874	418	354, 700	10, 048	66	41, 030	847	284	182, 517	4, 232	768	578, 247	15, 127
1875	370	310, 877	10, 102	67	39, 298	781	222	145, 748	3, 290	659	495, 923	14, 173
1876	355	320, 015	10, 348	58	40, 832	987	260	169, 649	3, 865	673	529, 495	14, 200

VESSELS CLEARED.

Year.	Coastwise.			American vessels for foreign ports.			Foreign vessels for foreign ports.			Total.		
	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.
1873	466	398, 050	13, 749	65	30, 102	699	224	129, 164	3, 194	755	554, 316	17, 642
1874	480	407, 295	12, 748	71	40, 397	822	229	145, 038	3, 437	780	593, 720	17, 007
1875	319	284, 831	9, 376	72	39, 311	804	195	128, 086	2, 924	586	452, 228	13, 104
1876	410	361, 999	11, 222	80	49, 483	1, 163	185	119, 699	2, 827	675	531, 181	15, 312

NOTE.—Very few vessels under enrollment, except steamers, enter or clear coastwise upon arrival or departure at or from this port.

Year.	Value of exports.	Value of imports.	Import duties collected.
1873	$32, 675, 500 00	....	$160, 011 77
1874	30, 213, 476 00	....	110, 492 74
1875	28, 949, 886 00	....	61, 625 44
1876	22, 681, 753 00	....	58, 163 36

H 3.

INSIDE PASSAGE BETWEEN THE SAINT JOHN'S RIVER AND FERNANDINA, FLORIDA.

No work was done upon this passage during the past fiscal year, as no appropriation had been made for it by Congress.

The channel, 40 feet wide and 4 feet deep, which during the previous fiscal year was opened by dredging through the shoals which obstructed the passage, at an expense of $7,372.40, was recently examined (on the 14th of June) by Capt. James C. Post, United States Corps of Engineers, assistant on the work, so far as it was practicable to do so in passing through on a steamer.

The following is his report thereon:

SAVANNAH, GA., *June* 22, 1877.

COLONEL: I have to report the result of an examination of the inside passage between the Saint John's River and Fernandina, Fla., made June 14, 1877, while passing through it on a steamer belonging to the regular freight-line which was established in June, 1876, after the completion of the dredging at the several places reported in the annual report for the fiscal year ending June 30, 1876.

Proceeding from Fernandina toward the south, through the Amelia River, the width and depth of the channel is ample for the navigation of vessels of moderate draught as far as the second reach before entering Kingsley's Cut. Through this latter, for a distance of 100 yards, there is but 4 feet at low-water; the width, however, is sufficient. Passing on to Kingsley's Cut and through it, between the piers of the Florida Railroad draw-bridge, which are only about 50 feet apart, there is sufficient water until the southern end of the cut is reached; here, for a distance of 100 yards, the channel is but 50 feet wide and 4 feet deep at low-water. Beyond this cut, in passing through the dividing basin of the Amelia River, for a distance of 200 feet, the channel at low-water, though sufficient in depth, is but 35 feet wide. Again, just to the south of this narrow portion, for a distance of 150 feet, the channel, which is sufficiently wide, is but 4 feet deep at low-water. From these divides, through South Amelia River to Nassau Sound, and from thence to Gunnison's Cut, Sawpit Creek, the channel is ample in width and depth.

Through Gunnison's Cut, where a channel 75 feet wide and 5 feet deep at low-water was dredged during the last fiscal year, there is now a channel-way at low-water of only 25 feet in width and 3½ feet in depth. At this place the material dredged consisted of soft mud and sand, which, when removed, was placed on the side of the cut, the balance on hand for this work not being sufficient to permit its removal to a point where it would not partially flow back again into the channel. Anticipating this flowing in, the increased dimensions were given to the dredged channel at this point, hoping thereby to gain a channel of some degree of permanence 40 feet wide and 4 feet deep at low-water. All of the steamers, however, that navigate this channel have side-wheels, which strike upon its sides as they pass through it and beat the material back again into the channel. It is largely due to this effect that this channel-way has become so contracted.

The remainder of Sawpit Creek and the Sisters' Creek remain the same as when the dredging was done, with the exception of the entrance of the latter into the Saint John's River. At this point the Oyster Shell Knoll, before reported, has formed a shoal which has reduced the channel to 25 feet in width and 2½ feet in depth for a distance of 75 feet.

Before the expenditure in dredging, made last year, this inside passage was practically unnavigable. As soon, however, as these slight improvements were made a weekly freight-line of light-draught steamers commenced their regular trips through it, from Fernandina to the Saint John's River, and have continued up to the present time; the freights of each month, I am informed, being greater than the preceding ones. During the past winter months a second weekly line was established, and there is every reason to believe that the majority of the commerce for the Saint John's River would follow this lead if this channel was properly opened, and thus avoid the bar at the mouth of the river.

The importance of opening a suitable channel-way through from Fernandina to the Saint John's River being thus demonstrated, I would respectfully suggest that an appropriation be requested for this work for the fiscal year ending June 30, 1879.

Very respectfully, your obedient servant,

JAMES C. POST,
Captain of Engineers.

Lieut. Col. Q. A. GILLMORE,
Corps of Engineers, U. S. A.

An appropriation for the enlargement of this passage is respectfully recommended.

This improvement is located partly in the customs-district and port of Fernandina and partly in that of Jacksonville. Such statistics of the commerce of these ports as I have been able to obtain are appended hereto in tables A and B.

The estimated cost of completing the improvement, as detailed in my report for the fiscal year ending June 30, 1875, was $160,000 to $370,000.

The amount expended since the adoption of the present project was $7,372.40.

No appropriation was made for the fiscal year ending June 30, 1878.

Amount that can be profitably expended in the fiscal year ending June 30, 1879, $25,000.

Entrances and clearances of vessels at the custom-house, port of Fernandina, Fla., in the years from 1875 to 1876 inclusive.

VESSELS ENTERED.

Year.	Coastwise.			American vessels from foreign ports.			Foreign vessels from foreign ports.			Total.		
	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.
1875	212	117, 363	4, 172	47	11, 818	359	12	4, 034	119	271	133, 215	4, 650
1876	220	141, 355	4, 749	25	6, 033	179	28	9, 232	269	273	156, 620	5, 197

VESSELS CLEARED.

Year.	Coastwise.			American vessels for foreign ports.			Foreign vessels for foreign ports.			Total.		
	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.	Number of vessels.	Tonnage.	Crew.
1875	229	121, 028	4, 303	31	8, 240	228	15	3, 543	160	275	132, 811	4, 691
1876	244	150, 154	5, 058	21	6, 038	155	26	9, 002	271	291	165, 194	5, 484

Year.	Value of exports.	Value of imports	Import duties collected.
1875	$220, 697	$7, 500	$1, 817 84
1876	218, 317	11, 398	2, 182 40

Entrances and clearances of vessels at the custom-house, port of Jacksonville, Fla., from 1870 to 1874, inclusive.

VESSELS ENTERED.

Year.	Coastwise.		From foreign ports.		Total.		Value of imports.
	Number of vessels.	Tonnage.	Number of vessels.	Tonnage.	Number of vessels.	Tonnage.	
1870	356	132, 673	13	(?)	369	(?)	$1, 464
1871	404	114, 928	13	2, 156. 86	417	117, 084. 86	728
1872	415	131, 240	15	1, 563. 78	430	132, 803. 78	3, 653
1873	463	146, 046	33	3, 980. 21	496	150, 026. 21	1, 947
1874	414	166, 092	30	4, 946. 59	444	171, 038. 59	3, 394

VESSELS CLEARED.

Year.	Coastwise.		For foreign ports.		Total.		Value of exports.
	Number of vessels.	Tonnage.	Number of vessels.	Tonnage.	Number of vessels.	Tonnage.	
1870	379	139, 231	25	4. 816. 94	404	144, 047. 94	$1, 511, 777
1871	394	114, 596	21	4, 956. 45	415	119, 552. 45	1, 395, 675
1872	446	153, 993	27	3, 098. 23	473	157, 091. 23	1, 606, 389
1873	484	156, 807	55	8. 667. 60	539	165, 474. 60	1, 978, 106
1874	420	174, 983	52	7, 137. 07	472	182, 120. 07	1, 990, 896

H 4.

SAINT AUGUSTINE CREEK, (THUNDERBOLT RIVER,) GEORGIA.

This river constitutes the inside passage between the Savannah River and Warsaw Sound, and is used by the small steamers plying between Savannah and Brunswick, Darien, Fernandina, and the Saint John's River.

The only improvement that is recommended, or that is deemed necessary, consists in the removal of a heavy-timber dry-dock sunk there during the civil war. It now lies directly in the channel, in 20 to 25 feet of water, and constitutes a very dangerous obstruction. A number of casualties of greater or less importance have already been caused by it. Its length is 225 feet, depth 25 feet, and breadth 65 feet; its thickness on the bottom being 3 feet, and on the sides 6 feet and upward. Its removal to a depth of 10 feet mean low-water will suffice.

No appropriation has ever been made by Congress for the improvement of this stream.

Appropriation recommended for this purpose, $5,000.

H 5.

OPERATIONS OF THE UNITED STATES DREDGING-STEAMER HENRY BURDEN.

NUMBER OF CUBIC YARDS DREDGED.

On the Savannah River:

	Cubic yards.
In the new channel at "The Wrecks"	57, 417
In the channel opposite Oyster-Bed Light	12, 012
In the channel northeast of Fort Pulaski	6, 395
Total, on the Savannah River	75, 824
Number of cubic yards dredged in Beach Channel, Charleston Harbor	680
Total dredged during the year	76, 504

EXPENDITURES FOR THE FISCAL YEAR.

For payment of master and crew	$8,702 49
For fuel	3,026 77
For supplies, (oils, paint, tallow, waste, rope, &c.)	570 62
For repairing and renewing machinery, &c., of steamer	465 54
For repairing and renewing machinery of pumping appliances	243 71
Total for the year	13,009 13

Of which was paid from the appropriation:

For improvement of Savannah Harbor and River, Georgia	$11,448 38
For improvement of harbor at Charleston, S. C	1,560 75

These figures cover all expenses for superintendence, wages and subsistence of crew, fuel, supplies, all necessary repairs to keep vessel and machinery in good order and prevent deterioration, and for the removal of worn-out portions of pumping apparatus.

	Cubic yards.
The greatest quantity of material dredged in any one day was	715
The greatest quantity of material dredged in any one week was	3,020
The greatest quantity of material dredged in any one month was	10,730
Average cost per cubic yard in eight months' work on Savannah River	$0 15$\frac{1}{10}$
Average cost per cubic yard in two months' work in Charleston Harbor	2 30
Average cost per cubic yard during the year	0 17

Had it not been for the special causes which made the dredging in Beach Channel very costly, the average cost per cubic yard during the year would not have exceeded 15$\frac{1}{10}$ cents. The average cost per cubic yard during the previous fiscal year was 21$\frac{1}{12}$ cents.

The appropriation for the Savannah River improvement having been exhausted, work was suspended July 12, and not resumed until September 12. After working three days it was found necessary to again suspend, owing to the prevalence of yellow fever in Savannah and vicinity, and the steamer was taken to Charleston Harbor, where an effort was made to deepen the Beach Channel. On account of the inadequate depth of water, it was, after numerous trials, found impracticable to work to any advantage, and the vessel was laid up until the subsidence of the yellow fever epidemic rendered it safe, on November 14, to resume work on the Savannah River.

H 6.

WATER-LINE FOR TRANSPORTATION FROM THE MOUTH OF SAINT MARY'S RIVER, ON THE ATLANTIC COAST, THROUGH OKEFENOKEE SWAMP AND THE STATE OF FLORIDA, TO THE GULF OF MEXICO.

UNITED STATES ENGINEER OFFICE,
New York, December 30, 1876.

GENERAL: I have the honor to submit the following remarks concerning a water-route for transportation from the mouth of Saint Mary's River, on the Atlantic coast, between the States of Georgia and Florida, through Okefenokee Swamp, and through the State of Florida, to the most suitable and convenient point on the Gulf of Mexico, a subject upon which I was requested to report by instructions from the office of the Chief of Engineers, dated November 3, 1876.

The points to which my attention was especially directed in the letter of instructions are the following:

1st. The character and nature of the project of improvement, the nature and probable extent of commerce and navigation interested therein, and how far the public interests will be benefited by the improvement when completed.

2d. The probable expense attending a reconnaissance or an examination sufficient to determine the feasibility of the project, with general estimate of cost thereof.

3d. The cost of such a survey as will be required for the purpose of preparing a project of improvement, with detailed estimate of cost.

The main purpose sought to be attained by the proposed water-line is assumed to be a cheap means of sending eastward the products of the Mississippi Valley over a route that shall shorten the time and avoid the danger of the trip through the Gulf of Mexico and the Florida Straits.

Two methods of accomplishing these objects suggest themselves:

1. By a water-line of barges across the peninsula of Florida, continued westward to the Mississippi River by another inside barge-route through the land-locked sounds and bays bordering the Gulf of Mexico in the States of Florida, Alabama, Mississippi, and Louisiana.

2. By a ship-canal across the State of Florida of dimensions sufficient to pass large ocean-going vessels.

1. BARGE WATER-LINE WITH INSIDE BARGE-CONNECTION WEST.

In determining the western terminus for a peninsula barge-canal from Saint Mary's River, through Okefenokee Swamp, to the Gulf of Mexico, the advantages offered by the harbor of Saint Mark's become at once apparent, whether considered with respect to either the inside or the outside connection west.

From Saint Mark's westward to Lake Borgne or Lake Pontchartrain there exists a nearly continuous natural land-locked water-route, by means of tidal sounds, bays, and connecting streams, requiring improvement by dredging in some places, it is true, but only a comparatively short aggregate length of solid cutting. The selection of a terminal point to the eastward of Saint Mark's would render the connection with this western branch to the Mississippi River less direct, and, it is believed, more costly for the entire line, although, perhaps, less so for the peninsula branch alone.

The chief object that is sought to be, and doubtless would be, attained by this canal is barge-transportation for the grain and cotton of the Mississippi Valley, and a portion of the cotton, timber, and lumber of the Gulf States, to some suitable harbor on the Atlantic coast, for reshipment to foreign and domestic markets.

The grain-barges used on the Mississippi River vary in tonnage from 600 to 1,500 tons, according to the stage of the river between Saint Louis and New Orleans. Their length varies from 180 to 220 feet, their breadth of beam from 30 to 40 feet, and their depth of hold from 6 to 9 feet. Assuming the largest size for fixing the dimensions of the canal, and omitting any present consideration of the water-supply, it follows that the trunk of the canal should have a bottom width of not less than 80 feet, with 9 feet depth of water. A less depth would inadequately meet the object in view, should the project for securing from 8 to 10 feet of water from Saint Louis to New Orleans, at the lowest stage of the river, recommended by the United States Senate Committee on Water-Routes to the Atlantic, be carried into effect.

It may be remarked here that the bar at the mouth of Saint Mark's River has upon it a minimum low-water depth of 8 feet, with a rise and

fall of 2.2 feet, while the river inside, as far up as the town of Saint Mark's, more than two miles from the bar, has a greater depth by several feet than can be carried over the bar.

It might, perhaps, be desirable to make the canal of even greater depth than 9 feet, unless restricted to that depth by an inadequate supply of water, so as to allow a numerous class of good-sized coasting-vessels to use it. In this case the Saint Mark's Bar would require deepening. Whether this is practicable by any method that shall be permanent, without being too costly, I am not prepared to say, having given no special study to the subject.

THE SOURCE OF WATER-SUPPLY.

The needed supply of water for the summit-level of the canal and the service of its two locks, and for all the various losses incidental to such works, is expected to be drawn from the Okefenokee Swamp. Its capacity for that purpose is unknown, although believed to be ample for the requirements of a barge-canal of the dimensions indicated, if judiciously located and cut to the requisite depth. This swamp, with the probable exception of less than 2 per cent. of its entire area, located within the State of Florida, has been surveyed or examined, in conjunction with a series of compass and level lines, at two different times, under direction of the authorities of the State of Georgia. The first examination was made by Lieut. R. L. Hunter in 1857. No copy of the map of this survey, but only some meager extracts from the text of the report, could be obtained. The second examination was made in 1875, by Mr. C. A. Locke, under the direction of Dr. George Little, State geologist of Georgia. A copy of the map and an abstract of the report have been received through the courtesy of Hon. J. M. Smith, governor of Georgia. While the aggregate number of facts collected from these sources furnishes much interesting and valuable information concerning the extent, the height above tide-water, and the characteristic topographical features of that locality, still the volume of water that may be drawn from the swamp and its water-shed for the service of the canal, and the practicability of its being utilized for that purpose at a reasonable cost, are questions which require additional and special observations and surveys for their determination.

It appears, however, from what is known of Lieutenant Hunter's report, that the highest part of Okefenokee Swamp is found at its northern extremity, where it is stated to be 126½ feet above tide-water, and that both its eastern and western borders have a gentle and nearly uniform declivity toward the southern end. At Ellicott's Mound, on the east, where a branch of the Saint Mary's River heads into the swamp, the height is said to be 111½ feet, and at Suwanee Shoals 110½ feet above tide-water. In fact, the map, referring especially to that of the northern part of Florida, compiled and published by the United States Coast-Survey Office, 1864, shows that the swamp is apparently fed by numerous creeks and rivers that enter it on its northern and northwestern borders, while the natural outflow takes place on its southern, southeastern, and southwestern borders, in the form of many water-courses, tributary to the Suwannee and the Saint Mary's Rivers. The swamp, in fact, occupies an extensive elevated plateau, from the southern end of which the Florida ridge springs, and thence extends southerly, with varying heights, until it disappears in the low swamps of the Everglades.

Lieutenant Hunter states that the area of Okefenokee Swamp is

about 625 square miles; that the Suwanee drains an area of the swamp and adjacent country equal to 670 square miles; and that the Saint Mary's River at Ellicott's Mound receives the drainage of 275 square miles, the whole area of swamp and adjacent country forming together the Okefenokee basin, being 945 square miles. In the absence of more precise information, this area will be assumed as the water-shed for supplying the summit-level.

Mr. Locke states in his report that the actual swamp covers about two-thirds to three-quarters of the entire area of what is called Okefenokee Swamp; and that the balance consists of numerous prairies, hummocks, and islands. The soil of the swamp proper is a soft muck, entirely saturated with water. In the dry season, about as much water as muck is visible. The growth in the swamp is cypress, bay, gum, and pine, with frequently an almost impenetrable undergrowth of intertwining bushes.

The so-called "prairies" are extensive level tracts, consisting of soft, easily penetrated muck soil about 5 feet deep, covered with perfectly clear water of a remarkably uniform depth of about 1 foot. These prairies have innumerable islands dotted over them, dry in the center, and of varying sizes; also, a few circular places called lakes—generally about one-fourth of a mile in diameter—in which the water is from 3 to 4 feet deep. The hummocks, lying between mainland and swamp, or between islands and swamp, contain rich, black soil, covered by a luxuriant growth of live-oak, hickory, &c., and form good agricultural lands. Of the islands, the largest named has an area of about 8 square miles, with soil the same as that of the surrounding country. The only growth upon it is long-leafed pine and saw-palmetto.

It might be conjectured, from the reports of Lieutenant Hunter and Mr. Locke, that not far from one-half of what is known as Okefenokee Swamp—or about 300 square miles—is covered with water during the dry season, but the depth of the water, except on the prairies and lakes, which, taken together, comprise but a small fraction of the entire area, is nowhere stated. It is not possible, therefore, to estimate, with any fair approximation to accuracy, the volume of water which the swamp contains. Neither is it possible to estimate the practicability and cost of increasing that volume by a dike around its low southern margin, so as to stop or diminish the present outflow, or of constructing such a system of interior trunk and branch ditches as shall effectively collect the waters of the entire swamp, and carry them off by one or more principal channels or feeders.

Okefenokee Swamp cannot, therefore, be considered as a ready-made natural reservoir for feeding the upper portions of the canal. It will require a certain amount—probably a very considerable amount—of engineering work to make its hydraulic resources available. This has been already pointed out in general terms in the report of the board of internal improvement on the contemplated canal between the Atlantic and the Gulf of Mexico, dated Washington, February 19, 1829, in which it is stated that, by a proper system of drainage, the standing water in the marshes of that extensive swamp may, at great expense, be made available. But the method by which this can best be accomplished, whether by enlarging the reservoir capacity of the swamp with a marginal dike, or by interior excavations, or both, or by constructing a reservoir elsewhere, if practicable, or by using the summit-level itself for that purpose, or by a combination of two or all of these devices, cannot be determined from any of the data furnished by previous surveys, so far as they have come under my observation.

One of the peculiar features of the river-system of Florida appears

to be that generally the streams force their way through the sandy upper stratum, and are fed more by lateral filtration than by tributaries. While the upper stratum of the peninsula is generally sandy on both sides of the Florida ridge, to a depth of at least 5 or 6 feet, the substratum is not the same on both sides. On the eastern it is clay mixed with a great deal of sand; but on the western side it is throughout a kind of stratified rotten limestone, presenting frequent outcrops on the surface, in many places undermined by streams which sink abruptly and force their way through the cavernous parts of the mass, to resume, at some distance away, their natural course upon the surface.

The porous, not to say spongy, condition of a very large portion of the soil of Florida, together with its comparatively insignificant elevation above tide-water, and the generally flat character of the country, particularly between the ridge and the Gulf, prevents the formation of tributaries to the few existing streams, while it is the cause of numberless lakes, ponds, and swamps that are generally found wherever a depression of the ground favors a collection of water.

What rivers there are have their volume gradually but steadily increased by constant infiltration from the water-soaked soil through which they flow.

From the experiments made by Lieut. John Pickett, and reported by him under date of Washington, March 6, 1832, it would appear that this element of water-supply by filtration may form an important factor in any canal-project for these regions. He sunk wooden shafts apparently 7 feet square in the clear, at several points in the valley of the Santa Fé and Bull Creek, about 45 miles south of the line upon or near which the summit-level of the proposed route would probably be located. After being pumped empty, the shaft in the Santa Fé Valley was observed to fill up with water to the height of nearly 16 feet in 7 hours and 37 minutes. In the valley of Bull Creek it rose 6 feet 7 inches in 2 hours and 44 minutes; and at Twenty-five Mile Point, 18 feet 6 inches in 6 hours and 41 minutes.

Similar but more numerous trials by shaft-sinking should be made, not only on the summit-section of the canal, but also in several places on the lower levels. The results will furnish important data for an estimate of the cost of the project, bearing more particularly upon the depth to which the trunk of the canal should be sunk below the natural surface of the soil.

The volume of water which escapes from the swamp by filtering away through the earth may be very considerable. It is not susceptible of direct measurement. Much of it, of course, finds its way into the Saint Mary's and Suwannee Rivers, and doubtless forms an important factor in their regimen. It is not deemed practicable to collect it for the service of the canal, although the summit-level may be expected to intercept and utilize a small fraction of it. Most of the tributaries to the Saint Mary's, which head up toward the east side of the swamp, do not appear on the map to tap it directly, though probably largely fed from it by infiltration, and they all join the main stream below the probable eastern terminus of the summit-level. There are two streams which have their source in the swamp, and flow due south into the Saint Mary's, that would be cut by the summit-line. On the west there are several streams which flow from the body of the swamp and empty their waters into the Suwannee above the point at which the western end of the summit-level would be likely to be established. A portion of this outflow could doubtless be diverted into the reservoir for the service of the canal to the greater or less injury of the navigation on the upper reaches of the Suwannee.

THE GENERAL CHARACTER AND LOCATION OF THE LINE.

A straight line, measured on the map, from the mouth of Saint Mary's to Saint Mark's, has a length of about 165 miles. By taking advantage of the natural water-courses in proximity to that line, which are either navigable or can presumably be made so by slack-water dams for the largest class of barges destined to pass the canal, the length will of course be augmented.

The total length of Saint Mary's River, from its mouth to Ellicott's Mound, where the head of one of its branches is found, is about 100 miles; but no information has yet been obtained as to how far vessels drawing 9 feet can ascend the stream in its natural low-river state, or to what extent and for what distance it is susceptible, at reasonable cost, of being converted into slack-water navigation. In the vicinity of Trader's Hill, which is something less than 50 miles above the mouth, a steamer drawing 17 feet of water is known to have been stationed, in the winter of 1864–'65, receiving a cargo of cotton from the interior of Florida. The tide is said to be felt as far as Barbour's, some ten or more miles above Trader's Hill.

An inspection of the map of Northern Florida shows that for a route through the Okefenokee Swamp to Saint Mark's, the Suwannee River, the most important natural water-course and the receptacle of all minor creeks and rivers in that region—such as the Withlacoochee and Alapaha—will probably, if not necessarily, form a part of it. Assuming this to be the case, the next point which presents itself is the selection of a canal-line that shall most advantageously connect the waters of the Suwannee and Saint Mary's Rivers.

By the survey of Major Perrault, as reported by General Bernard, February 19, 1829, the summit-point of the then contemplated route was fixed near the southern end of the Okefenokee swamp, and found to be 152 feet above low tide. Its location was 12¾ miles west of the fork formed by Saint Mary's River and Alligator Creek. The distance from the summit-point to a certain point on Saint Mary's River near Barbour's, on a gently curved line, forming a part of the then proposed route, was found to be 27 miles, while following the windings of the river it would have been over 50 miles. From gauging the river in those parts, it was concluded that its average discharge per second was entirely inadequate for canaling purposes, and that the whole length of 27 miles east of the summit-point would have to be fed by a reservoir. Again, at about 18 miles west of the summit-point the Suwannee is struck, which is stated to discharge at that place 614 cubic feet of water per second at ordinary stages. This amount being ample for all the purposes under consideration, suggests the location of the western terminus of the connecting canal at that point. In that case its length would be about 45 miles.

The heights and distances above given can only be accepted as approximately correct.

This part of the project will require an especially careful study, and the running of several trial and level lines, before an estimate of the cost of this portion of the work can be formed.

Following the Suwannee to Columbus, it receives on its course the rivers Alapaha and Withlacoochee. At the mouth of the latter the discharge of the Suwannee was stated by General Bernard to be 3,000 cubic feet per second. From Columbus it may be advisable to follow the Suwannee farther down, instead of striking directly for Saint Mark's, whereby the high plateau extending toward Tallahassee would be en-

countered. Descending the river, therefore, as far, perhaps, as Charles Ferry, a distance of about 50 miles, the route would then turn to the westward, crossing in succession the Fenholloway, Econfenee, and Ocilla Rivers; thence running through the low marsh-land near the Gulf to the terminal point in the Saint Mark's River, about 70 miles from the Suwannee.

The probable nature and character of the project may therefore be summed up as follows: It will be a water-line for barges of 9-foot draught or less, commencing at the mouth of Saint Mary's River; thence ascending that stream as far, perhaps, as it is navigable, or can be made so at reasonable cost by slack-water dams and otherwise; thence by canal and locks across the southern portion of the Okefenokee Swamp to the Suwannee River; thence descending that river by slack-water and open river navigation to a point near the vicinity of Charles Ferry, though possibly at some distance therefrom, and thence in a direction nearly due west by canal to the western terminus in deep water on the Saint Mark's River, a little below the town of Saint Mark's.

The project will doubtless comprise the excavation of an extensive storage reservoir for receiving the drainage of Okefenokee basin, either detached from or forming a part of the summit-level, with a more or less thorough system of drainage of the swamp, the removal of obstructions, such as shoals, bars, snags, sharp bends, &c., in the Saint Mary's, Suwannee, and perhaps other minor rivers, the excavation of two detached sections or divisions of canal, aggregating over 100 miles in length, and the construction of slack-water dams, lift and guard locks, &c.

From what is known of the general route it is presumed that the lengths of the several subdivisions of the line will not vary greatly from the following:

	Miles.
1. From the mouth of Saint Mary's River up that stream	61
2. From the Saint Mary's to the Suwannee River, by canal and locks	45
3. Suwannee River to Charles Ferry	50
4. Charles Ferry to Saint Mark's, by canal	70
Total from mouth of Saint Mary's River to Saint Mark'se	226

WATER-EXPENDITURE.

Although, as already stated, the capacity of the Okefenokee basin and swamp for supply of water is not known, the volume that it would be required to furnish for a canal of given dimensions, that shall most advantageously connect the waters of the Saint Mary's and Suwannee Rivers, may be roughly computed.

The length of the summit and adjacent sections of the canal that would have to be fed from a storage-reservoir was estimated by the board of internal improvement, in 1829, at about 45 miles, and since there are no data whatever on hand at this time to justify or require the adoption of any other summit-line, it will be used as a basis for calculation.

It was suggested by that board that inasmuch as no natural reservoir of any consequence exists on the top ridge, it would be necessary to construct the summit-level of sufficient capacity to be itself a reservoir to be supplied from the Okefenokee Swamp.

The minimum dimensions assumed for the canal are a width of 80 feet at the bottom and 116 feet at the water-surface, giving side-slopes of 1 upon 2, and a depth of 9 feet. A 1,500 ton grain-barge has a width of 40 feet. Twice that number, or 80 feet, gives the minimum width at the

bottom. The cubical contents of the canal-prism forming the summit-level will be, therefore, 209,563,200 cubic feet, or 7,761,700 cubic yards.

The loss by evaporation on this length of 45 miles will amount to just about one water-prism per year, assuming, according to the results of Lieut. M. L. Smith's studies of the subject in reference to a canal-route connecting with the Saint John's River, Florida, the monthly evaporation in that climate to be 7½ inches, or 7 feet 6 inches per annum, (7½ feet × 116 feet × 45 miles = 7,655,000 cubic yards.)

The loss by absorption and infiltration is taken to be about 14 prisms per annum. This estimate is based upon observations made on canals constructed in soils differing widely in many respects from that through which the summit-level will pass, and is doubtless much too high. It is believed that the losses from these causes near the surface will be compensated in great measure by water flowing into the canal from the more or less thoroughly saturated subsoil. It will, however, be assumed that 14 prisms are annually lost in this manner.

The loss by leakage at the lock-gates has been generally calculated among American engineers to be 12 lockfuls a day per lock, or 24 lockfuls for the summit-level with its two locks, equal to 8,760 lockfuls per year. The dimensions of a lock are supposed to be 250 feet by 50 feet, with a lift of 8 feet. One lockful, therefore, amounts to 3,333 cubic yards, and 8,760 lockfuls to 29,197,080 cubic yards. This is equivalent to about 4.17 water-prisms per annum.

Loss by lockage.—A first-class barge will probably, on the average, occupy about 30 minutes in passing a lock. Reckoning the actual working time at 18 hours a day, 36 boats per day will pass the summit-level, when employed to its full capacity, with a single set of locks. The maximum consumption of each boat will be two lockfuls, the daily loss by lockage will therefore be 36 × 2 = 72 lockfuls, or 26,280 lockfuls per annum, equal to about 12.53 prisms. Finally, the loss by draining off portions of the canal for repairs may be put down at 3 prisms.

Recapitulating these various losses, a total loss of 34.70 prisms is found, viz:

	Prism.
Loss from evaporation	1
Loss from absorption, infiltration, &c	14
Loss from leakage at lock-gate	4.17
Loss from lockage	12.53
Loss from emptying portions of the canal	3
Total	34.70

This volume of 34.70 prisms, equal to 269,380,978 cubic yards of water, must be supplied to the canal every year to keep it in navigable order; or, in other words, the canal supposed to have been filled ready for service will require an additional volume of water, amounting to 231 cubic feet per second, to make up for losses.

The volume of water required for the service of the locks may, of course, be diminished in several ways, at an increased outlay for construction, either by means of intermediate gates, which will divide the locks into two shorter lengths, suitable for vessels of less than the maximum length, or by building smaller locks beside the large ones, for the use of such vessels; or by the construction of lateral storage-basins in connection with each lock into which the upper portion of the prism of lift would be discharged at the passage of each boat, to be returned to the lower portion of the prism when filling the lock for the next boat.

Although the foregoing estimate supposes that the highest reach of the canal extends from river to river, and is attained from either stream

by a single lock, it will probably be found that the length of the summit-level will not exceed 35 or 40 miles, and that on the Saint Mary's end five or six locks may be required, and on the other as many as four or five, but that in neither case will these locks be required to be in flights.

WATER-SUPPLY PROBABLY AVAILABLE.

Accepting Lieutenant Hunter's estimate of the area of Okefenokee basin at 945 square miles, (or 26,345,088,000 square feet,) it follows that a rain-fall of 3.32 inches over the entire area must be utilized for the service of the canal. As to the amount of rain-fall at Okefenokee basin, Lieut. M. L. Smith says, in his report, that at Tampa Bay the yearly rain-fall is 57 inches; at Fort Meade, 35 inches; at Fort Pearce, 73 inches; at Jacksonville, 58 inches; giving an average fall for the four places of 56 inches. This agrees with Col. P. H. Raiford's statement, in his examination before the Senate select committee, December 24, 1873, wherein he gave the average rain-fall at Okefenokee basin during each of the four seasons, and computed the mean annual rain-fall there at 55 inches. Adopting the latter figure, 55 inches, and having found 3.32 inches of rain over the whole basin to be needed for supplying the summit-level of the canal, we arrive at the conclusion that whatever be the mode of storing the water gathered by drainage, 6.04 per centum of the total rain-fall must be rendered available for canalling purposes, in addition to all losses by evaporation, leakages, &c., in the storage-reservoir and feeder.

If we assume the water to be collected in such a reservoir, its volume will be continually diminished by evaporation in a direct ratio to its surface-area, and an inverse ratio to its depth; but it will doubtless be replenished to some extent by inflow from the water-soaked subsoil, so that the allowance to be made for reservoir-evaporation cannot be estimated with any confidence in the accuracy of the results.

If it should be found practicable by any system of dikes to use a portion of the swamp as the storage-reservoir, the loss by evaporation, although large, may be approximately computed. It will go on over the entire water-covered area, with the exception of the small portion occupied by hummocks and islands.

In considering the question of using a portion of the swamp as a storage-reservoir, it is desirable that its surface-area should be restricted as much as possible, in order to reduce the loss from evaporation.

The annual loss from this cause has been assumed to be $7\frac{1}{2}$ feet, and the supply of water needed for the summit-level at 231 cubic feet per second. If the area of the reservoir in square miles is designated by A, we have the following:

(1) Loss per second from evaporation on surface of reservoir $= \left(\frac{5280^2 \times 7\frac{1}{2}}{31,536,000}\right) \times A$

(2) Loss per second to feed summit-level and locks = 23 cubic feet.

The annual rain-fall being taken at 55 inches, or $4\frac{7}{12}$ feet, the area of the reservoir, equal to A square miles, receives the whole height of water due to that rain-fall. Of the rain-water that falls on the other portions of the Okefenokee basin, it is assumed that but one-fourth of it can be conducted by drainage to the reservoir; the balance is supposed to be lost by evaporation, leakage, and other causes.

The available drainage-area is 945—A square miles.

(3) Supply by direct rain-fall on reservoir $=\left(\frac{5280^2 \times 4\frac{7}{12}}{31,536,000}\right)\times A$

(4) Supply by draining balance of basin one-fourth of rain-fall .... $\left(\frac{5280^2 \times \frac{1}{4} \times 4\frac{7}{12}}{31,536,000}\right)\times (945-A)$

Consequently $A = 202$ square miles.

Hence the storage-reservoir, if constructed within the Okefenokee basin, must not exceed 202 square miles in area, assuming it to receive only one-fourth of the rain-fall of the balance of the basin.

The reservoir will be subject to the following losses in addition to the loss by leakage:

	Cubic feet.
Annual loss from evaporation	42, 260, 657, 250
Annual loss from feeding summit-level	7, 273, 286, 400
Total	49, 533, 943, 650

On the assumption that the canal passes through the lowest or southern portion of the swamp, a part of the loss by leakage will be interrupted by the summit-level, and to that extent will diminish the amount to be supplied through the feeder.

If the storage-reservoir be required to have a capacity equal to four months' supply, it must hold $\frac{1}{3}$ of the last given amount, and be 3 feet deep.

By increasing the depth of the reservoir its area will be lessened, and may reach a minimum when the summit-level is made to serve as a reservoir. In the latter case, the canal proper may run through the reservoir as a deeper channel, so that when the reservoir shall have had its water-level lowered by a long-continued drought, there will still be enough depth of water in the channel proper.

Whichever way this question will be solved, the necessity of a very considerable amount of excavation cannot be avoided; but some important elements that will enter into any calculation are at present so little known as to their relative value, that the above calculation, and any other made now and bearing on the subject, can be only considered as an essay. The soil of at least a large portion of Florida is of such an exceptional character that only a series of careful experiments made on the proposed site of summit-level and reservoir can decide the question whether filtration should be taken into account as a source of supply or of loss. In regard to this matter, it may be in place to recall the conclusions arrived at by the board of internal improvements (General Bernard's report) in discussing a route the summit-level of which was to be fed by Kinsley's and Sampson's Ponds, about 45 miles south of Ellicott's Mound. The report says that—

The two ponds will furnish the necessary water for lockage; but with regard to the prism of the level, about twenty-five miles in length, it has to rely entirely on the resources derived from infiltration through the ground. *Therefore the practicability of the canal rests altogether upon this point.*

The following observations, made by the board during their examination of the peninsula of Florida, lead them to anticipate a favorable result:

1st. The sandy upper stratum and the rotten limestone substratum will facilitate the filtration to a high degree.

2d. The ponds on the summit of the ridge are chiefly kept full by filtration.

3d. The numberless ponds, of various sizes, scattered everywhere on the surface of the peninsula, form a strong indication of the facility afforded by the ground for the transmission through it of water to inferior levels.

4th. The main streams of the peninsula have few tributaries. They are, however, flush during the warm season, and suddenly swelled by accidental heavy showers. This shows that they must, chiefly, receive their supply from filtration.

The reduction of the water-surface of the storage-reservoir to the least practicable dimensions will have the advantage of reclaiming a very large portion of the lands of Okefenokee Swamp and will compensate to some extent for expenses incurred in forming the reservoir. These reclaimed lands will be valuable through their proximity to the canal, affording ready means for shipping their produce either to Gulf or Atlantic ports. These facilities will be still more increased by making at least the main drain through the swamp of such dimensions as to render it to a certain degree navigable. As a case in point, the reclamation of the fens or overflowed lands bordering the river Ouse and its tributaries, in England, may be mentioned, now known as the Bedford level. These fens covered an area of 400,000 acres, (equal to 625 square miles, the reputed size of Okefenokee Swamp.) Several unsuccessful attempts to improve the tract were made as early as the fifteenth century, and were renewed in 1634 by the Earl of Bedford, who in three years expended £100,000 without favorable results. In 1649 his son recommenced operations, and succeeded, after an expenditure of £300,000. Among the numerous drainage-channels cut through these lands are two nearly parallel to each other, more than 20 miles in length, and both navigable.

Moreover, by the application of modern machinery, it is to be expected that the swamps and overflowed prairies of the Okefenokee basin can be changed into fine and fertile agricultural land at an economical rate.

From the report of the United States Commissioner of Agriculture for 1874, it appears that in Colusa County, California, the Tule Land Reclamation Company gives employment to 400 or 500 men. The company owns 42,000 acres of overflowed swamp land, and with the aid of a powerful steam-ditcher, it is estimated by the company that it costs but $2 an acre to reclaim it. Before the civil war it was estimated by the rice-planters of the South, with abundant slave-labor at command, that it cost about $150 an acre to reclaim cypress lands, and about $100 an acre to reclaim marsh lands.

The work done by the steam-ditcher is of the most thorough kind, erecting in its course an embankment 20 feet wide at its base, 4 feet wide on top, and 4 feet high. The worthless land reclaimed by this work now produces 40 bushels of wheat to the acre, and it at once rose in value to $15 per acre.

The average value of land in Georgia was, in 1860, $4.85. The highest value in the richest county was $10.66 per acre. The lowest value was 68 cents per acre. In 1866, immediately upon the close of the civil war, the average value of land was $3.42, showing a diminution from the value of 1860 of $1.43 per acre. There has been a slow advance in value from 1866 to the present time, the average value nearly, if not quite, reaching that of 1860. The lands of some sections have actually increased in value since that date in many instances to $50 per acre, while others have decreased from $20 and $30 per acre to from $3 to $5 per acre.

Okefenokee Swamp proper is said to contain six hundred and twenty-five square miles, or four hundred thousand acres, which are at present worthless. If, through improvement by drainage, the land is made worth only the average value of land in Georgia, or $4.85 per acre, the aggregate value of the reclaimed swamp-lands will be $1,940,000. But it is quite probable that, the canal having been made and the lands fairly brought under cultivation, they will be worth considerably more than

this in the market, owing to the facilities for the transportation of their crops offered by the convenient proximity to the canal.

It is believed that arrangements might be made with the State of Georgia by which nearly if not all of the Okefenokee Swamp would become the property of the United States on condition that the canal be constructed.

Saint Mary's River flows into the ocean through the outlet of Cumberland Sound, where there is now only 11 feet of water on the bar at mean low tide, with an ordinary rise and fall of 5.9 feet. The bar-channel is, however, unusually shallow at the present time, its normal low-water depth for a series of years, and until quite recently, having been 13 feet, and it may perhaps be safely assumed that this depth can be established and maintained at a moderate cost, allowing vessels drawing 16½ to 17 feet to pass out and in on the flood-tide in calm weather.

The hydraulics of Cumberland Sound, so far as the meager data on record have enabled the engineering questions connected therewith to be made the subject of study, do not seem to be favorable to the permanent improvement of the entrance by means of artificial works, although the construction of jetties at a cost of $2,000,000 to $2,500,000 would for a time—certainly for a few, and possibly for many, years—afford a channel of ample depth for ocean-going vessels of large size.

It is not necessary, however, to use this outlet for shipping the freight delivered by the canal. There are better harbors to the north of Cumberland Sound, and connected therewith by a natural inside water-passage.

Saint Andrew's Sound, twenty-three miles distant, and Brunswick Harbor, thirty-five miles distant, have good channels of entrance and good anchorages inside. The low-water depth on the Saint Andrew's Bar is 16 feet, and that on the Brunswick (Saint Simon's) Bar 17 feet, with a mean rise and fall at the former of 7.1 feet, and at the latter of 6.8 feet.

Brunswick appears to possess superior advantages as a shipping-port for the Florida canal, and the inside passage which connects it with Saint Mary's River can probably be improved for 9-foot barges at an expense not exceeding $125,000. An examination of a few points of the line is necessary before a close estimate of the cost can be made.

A SHIP-CANAL.

The feasibility of a ship-canal for large ocean-going vessels that shall connect the Saint Mary's River with the Gulf of Mexico through Okefenokee Swamp is, of course, vastly more problematical than that of the barge-canal already discussed. The project must provide for a suitable harbor at each terminus of the line. On the Atlantic, as in the case of the barge-line, this could possibly be accomplished in a satisfactory way by the construction of jetties at the entrance of Cumberland Sound, or better still, and with certainty, by the enlargement for ships of the existing inside passage between Saint Mary's River and Brunswick, making this point the shipping port.

On the Gulf side the choice would probably have to be made between Saint Mark's and Cedar Keys, as they are the only harbors at all near the direct line possessing sufficient natural depth of water approach to encourage any attempt to enlarge them to the required capacity by the construction of artificial works, and I am not prepared to assert that either of them is susceptible of such improvement. On the Saint Mark's

Bar there is a depth of 8 feet, and on the Cedar Keys Bar a depth of 9 feet, at mean low-water. If Saint Mark's should be selected for the Gulf terminus, the general location of the route would probably not vary greatly from that of the barge-line, while if it should run to Cedar Keys the Suwanee River, from the western end of the summit-level division to some point near its mouth, would most likely form a part of it, the terminal point being reached by a cut 13 to 15 miles long through the low marshes to the southward of that stream. This assumes that the bar at the mouth of the Suwanee is not susceptible of improvement. I am not in possession of any recent information concerning it, and no chart of it has been issued by the Coast-Survey establishment. Official reports show that some years ago it was not considered safe for a vessel drawing over 5 feet to attempt its passage, even on the high tide.

The character and nature of a project for a ship-canal having its Gulf terminus at Saint Mark's would therefore comprise—

1st. The improvement of the entrance to Saint Mary's River (Cumberland Sound) by artificial works, or the enlargement for ships of the inside passage northward from the mouth of that river to Saint Andrew's Sound, 23 miles distant, or to Brunswick Harbor, 35 miles distant, by the channel line.

2d. The improvement of Saint Mary's River for slack-water navigation or otherwise up to some suitable point for commencing the ascent to the summit point.

3d. The construction of the summit-level and adjacent sections by solid cutting, with the required number of locks to connect the waters of the Saint Mary's and the Suwanee Rivers.

4th. The excavation of a capacious storage-reservoir for receiving the drainage of Okefenokee Swamp, including the necessary work for draining the swamp and feeding the canal.

5th. The improvement of the Suwanee River for slack-water navigation, or otherwise, from the last lock at the western end of the summit-level division to some point not far from Charles Ferry.

6th. The construction of a ship-canal by solid cutting from the Suwanee River to deep water in the Saint Mark's River, near its mouth.

7th. The improvement of the channel of entrance to Saint Mark's River by artificial works.

If the line runs to Cedar Keys the work will be the same as above noted from Cumberland Sound to the Suwanee River. Beyond that it will comprise—

5th. The improvement of the Suwanee River, from the western end of the summit-level division to deep water near its mouth.

6th. The construction of a canal through the marsh south of the Suwanee River, near its mouth, to deep water at Cedar Keys.

7th. The improvement of the channel of entrance to Cedar Keys by artificial works.

COMMERCIAL ADVANTAGES OF THE BARGE-ROUTE.

With respect to the nature and probable amount of commerce and navigation interested in the construction of the route under consideration, and the extent to which the public interests will be benefited by the improvement when completed, a few remarks are offered.

Conclusions upon a subject so important as this should be drawn only after a study of all available sources of information, including agricultural, industrial, and commercial statistics, whether furnished by Government departments, corporations, or individuals, comprising an aggre-

gate mass of materials of various kinds, trustworthy and otherwise, of such vast proportions that its mere collection, to say nothing of its thorough examination, would require more time than I have been able to spare from my other duties.

The discussion of this branch of the subject is therefore entered upon with reluctance, under a lively sense of the incompleteness of the data at command.

As to the probable effects on commerce and navigation of the proposed barge-route, it is presumed that it is not to be considered as a separate or isolated work of improvement, but as forming a part of a great and continuous water-route from the Upper Mississippi and its tributaries to the Atlantic seaboard. Thus connected, it would represent the eastern terminal branch of that line, forming the transit route from the Gulf to the ocean.

The leading object to be secured through this line is the cheap and safe transportation, in unbroken bulk, of the surplus produce of a very large portion of the Western and Northwestern States, by means of the Mississippi River and a secure land-locked water-route, to a convenient harbor on the Atlantic coast, for export to foreign countries or for consumption in the Atlantic States.

The necessity for larger facilities for such transportation is becoming more serious and imperative every year, in proportion as the population of the agricultural States and the area of land brought under cultivation increase.

The census reports show that certain of the States, comprising Ohio, Michigan, Indiana, Illinois, Wisconsin, Minnesota, Iowa, Missouri, Kansas, and Nebraska, have increased in a much more rapid ratio than the balance of the United States, both as to population and aggregate amount of agricultural products. Table I, hereunto appended, shows that from 1850 to 1860 their population increased 68 per centum, that of the other States 25.7 per centum, while from 1860 to 1870 they showed an increase of 42.6 per centum, the other States only 14.5 per centum. Similar facts are exhibited in the same table, in the column of "Increase or decrease," in the production of cereals generally as well as of wheat and corn. It will be observed that in 1874 a general decrease in the production of grain occurred, while that of wheat was considerably increased; in fact, the wheat-crop of 1874 was considered the largest thus far obtained.

By referring to appended Table II, it is seen that in 1874 the total wheat production of the United States was 308,093,700 bushels, of which 198,928,000 bushels were grown in the above-named ten Western States. This increase in wheat production has been entirely due to the increase of cultivated area, as stated in the report of the Department of Agriculture.

Wheat being the most valuable of all cereals, it appears natural that the area of its production should extend more rapidly than that of other grains, since it is able to bear higher rates of freight.

How largely the acreage devoted to the cultivation of wheat and the demand of this cereal for export have increased is plainly seen from the reports of the Department of Agriculture. In 1872, the number of acres planted with wheat in the ten grain States was 13,811,008, producing 156,228,000 bushels, (see Table II,) of which about 74,000,000 bushels were shipped to other points of the United States or to foreign countries.

In 1874, these ten States had 15,746,124 acres planted with wheat, producing 198,928,000 bushels. The population of these States is esti-

mated at 14,500,000, and, allowing a consumption of 5 bushels per head per annum and 1¼ bushels for seed per acre, we have available for shipping 102,808,000 bushels.

Flour and grain movements have been enormously increased since 1872, according to the same report. The foreign shipments from ports of the United States of all kinds of grain (wheat, corn, rye, oats, and barley) have been as follows during the years 1870 to 1874, inclusive:

	Bushels.	Value.
During fiscal year ending June 30, 1870	55,827,508	$72,485,775
During fiscal year ending June 30, 1871	62,937,759	79,519,387
During fiscal year ending June 30, 1872	79,632,238	85,155,523
During fiscal year ending June 30, 1873	92,315,152	99,090,831
During fiscal year ending June 30, 1874	128,642,760	161,755,748

The exports of all kinds of grain of each year as compared with the previous year increased as follows, both as to quantity and value:

1871 over 1870: increase of grain exports in quantity, 13 per cent.; in value, 13 per cent.
1872 over 1871: increase of grain exports in quantity, 26 per cent.; in value, 6¼ per cent.
1873 over 1872: increase of grain exports in quantity, 16 per cent.; in value, 16 per cent.
1874 over 1873: increase of grain exports in quantity, 40 per cent.; in value, 63 per cent.

The exports of all kinds of grain in proportion to the aggregate amounts raised in the United States have likewise increased; that of wheat remarkably so, as already mentioned, and, as seen from the following table:

Exports expressed in percentages of the aggregate production of the United States.

Year.	All grains.	Wheat.	Corn.	Oats.	Barley.	Rye.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1870	3.1	20.7	0.15	0.04	0.9	0.70
1871	3.8	22.3	0.9	0.06	1.3	0.23
1872	5.2	16.9	3.9	0.10	0.3	5.17
1873	5.5	20.8	3.5	0.26	1.8	3.7
1874	8.4	32.5	3.7	0.30	1.0	10.3

This table shows clearly the growing dimensions of the foreign grain-trade. We may conclude that if this commerce has been able to increase at such a rate with the present insufficient facilities for the eastward movement of grain, there is a fair prospect of a still more important development after the cost of transportation to sea-ports shall have been by suitable means permanently fixed at sensibly lower rates.

In the report of the Senate Committee on Transportation-Routes to the Seaboard, of April 24, 1874, it is stated that in 1872 the aggregate amount of wheat, corn, rye, oats, and barley raised in the ten grain States was 1,028,987,000 bushels, which was disposed of as follows:

		Bushels.
Consumed in the States in which produced		815,955,574
Consumed in the Atlantic States	104,877,122	
Consumed in the Gulf States	33,783,526	
Consumed in foreign countries	74,360,778	
		213,021,426
Production of the ten grain States		1,028,977,000

The population of the grain States in 1872 has been estimated (Table II) at 13,740,000; the home consumption in these States having been found to be 815,955,574 bushels, the consumption per capita of all sorts

of cereals was nearly 60 bushels. This large quantity per head includes not only the amount used for human food, but also for all other purposes; and a large portion of it is therefore exported to other States or foreign countries, in the shape of spirits, live-stock, provisions, &c. There can be little doubt that the immense pork-trade of the West stands in an intimate relation to the matter of cheap transportation. The high rates of freight and inadequate means of transportation for the surplus produce of the West practically shut off a large portion of it from the market, and compel the producer to change it into more compact or concentrated, although less profitable, forms, in order to prevent such surplus of grain becoming a dead loss on his hands.

Lowering the rate of freight is equivalent to a reduction of the distance of the great centers of agriculture from the centers of commerce on the Atlantic coast. As an example of the influence of distance on the value of farm-products, the following table, compiled from the United States Census Report for 1870, is given. The number of bushels given is the aggregate sum of the principal cereals raised—that is, spring and winter wheat, Indian corn, oats, rye, barley, and buckwheat.

The fourth column gives the total value of all farm-products, including live-stock, and the fifth the value of the cereals.

Table showing the influence of distance on the value of farm-products.

Name of State.	Head of live-stock.	Bushels of grain.	Total value of all farm-products, including live-stock.	Value of cereals.
New York	5, 286, 521	89, 930, 150	$253, 526, 153	$78, 643, 441
Pennsylvania	4, 484, 748	117, 492, 934	183, 946, 000	68, 298, 923
Illinois	6, 926, 028	207, 936, 491	210, 860, 585	61, 103, 486
Missouri	5, 417, 597	97, 793, 338	103, 035, 759	18, 750, 4-6
Iowa	3, 674, 763	121, 951, 917	114, 386, 441	31, 399, 308
Kansas	819, 214	23, 726, 086	27, 630, 651	4, 457, 466

The foregoing table shows that the State of New York had but 76.3 per centum of live-stock, and only 43.3 per centum of bushels of grain, as compared with Illinois; yet the total value of its products exceeded that of Illinois by $42,665,568. Missouri had 131,076 head of live-stock and 7,863,188 bushels of grain more than New York; yet the total value of its products amounted only to 40.5 per centum of those of the latter State. Similar comparisons can be deduced from the table indicating the diminution of value by increased distance from market.

In volume III, Ninth Census Report, (1870,) the remark occurs:

> It is sufficient barely to allude to such notorious facts as corn selling in New England at ninety cents and being burned for fuel in Iowa; wheat selling at $1.35 in New York and for forty-five cents in Minnesota; beef bringing $7 a hundred on the hoof in the East, while cattle are being slaughtered for their hides in Texas.

It may be said that the exceptional state of affairs under which cattle are killed for their hides no longer exists in Texas, or is practiced only by a class of thieves known as "cattle-peelers."

The only existing through water-route from the Northwest to the seaboard is by way of the lakes, with Chicago as the chief receiving depot in the West. Most of the grain received at Chicago comes by rail from the interior of Illinois and Iowa. The lake route at its eastern

terminus branches off into the Canada route, by way of the Welland and Saint Lawrence Canals, with Montreal as the shipping-point, and into the New York route by way of the Erie Canal and Hudson River, with New York as the terminal point on the Atlantic coast.

While the great lakes offer unbounded facilities for shipping purposes, both lines of canal have been found to be insufficient to meet the requirements of the fast-growing West. Although several through freight-railway lines have lent their aid to moving the crops, yet, while they are most dangerous competitors to the canals in their present condition, their rates are necessarily too high for shipments from the most remote grain-districts.

The evidence elicited before the Senate committee shows that facilities of transportation cannot be multiplied fast enough to relieve the wants of the Western States, and to ameliorate the ruinous condition of things where, as in the far West, it takes the whole production of three acres to transport that of one acre to market.

In addition to the deficient capacity of the above-named canals, their actual working-time is limited to about two hundred and ten days in the year, being ice-locked during the remainder of the time. Millions of bushels are thus kept shut up in the elevators of Chicago and Buffalo waiting for the re-opening of navigation, while other millions must be carried eastward by rail, upon which the rates are always raised when the competition of the canals ceases. The inconvenience caused by frost is illustrated by the fact that, in 1872, 10,000,000 bushels of grain were caught on the Erie Canal by one night's freezing.

The lack of cheap connection of the grain-districts west of Lake Michigan with Chicago has led to the so far but partial construction of water-routes connecting the Upper Mississippi with said lake. These lines are known as the Fox and Wisconsin River improvement, and the Rock Island and Hennepin Canal. Both will afford beneficial competition with parallel railway lines, lower the rates, and, in connection with the lake-route, will complete the great northern water-route from the Upper Mississippi to the Atlantic coast.

The pressing necessity for creating additional means of transportation has led to the consideration of other lines. These are—

The grand central route, from the mouth of the Ohio River to Hampton Roads, a length of about 1,400 miles by way of the James River and Kanawha Canal, at an estimated cost for the passage of boats of 345 tons of from $50,000,000 to $60,000,000. The advantages claimed for this line are that it will open a cheap channel of transportation to the Atlantic for the cereals of the West, and develop vast resources of coal and iron, now almost worthless, in Virginia and West Virginia.

The great southern or Atlantic and great western route, connecting the Tennessee River by canaling with the Coosa, Ocmulgee, and Altamaha Rivers, and thence to Brunswick or Savannah, as the terminus on the Atlantic coast. The western terminal point on the Mississippi of this route, as well as of the preceding one, will be Saint Louis. Its cost is estimated at $35,700,000, its length from Saint Louis to Savannah by way of Cairo 1,574 miles, and its probable working-capacity at 154,000,000 bushels per annum, assuming boat-cargoes of 300 tons. It is claimed that this line will be absolutely free of ice.

The Mississippi and Florida peninsular route, comprising the Mississippi River from Saint Louis to New Orleans, thence by an interior line along the Gulf coast to Saint Mark's, and thence across the peninsula of Florida by canal, slack-water, and open river navigation to Saint Mary's, on the Atlantic Ocean.

In considering this route the most important question seems to be the probable cost of moving grain from Saint Louis to its terminus on the Atlantic seaboard. From the report of the Senate committee we find that the average freight-charges from Chicago to New York, and from Saint Louis to New York, were found to be as follows in the year 1872:

FIRST STATEMENT.

		Cents.
Average freight-charges from Chicago to New York by lake and canal, rate per bushel		26.6
Average freight-charges from Saint Louis to New York:		
Saint Louis to New Orleans, (average for the year)	13.9	
New Orleans to New York, (average for the year)	13.7	
		27.6
Loss by lakes and canal		1.0

Adding transfer-charges and marine insurance, we obtain the total cost of transportation in each case, as follows:

	Cents.
Total cost of transportation from Chicago to New York	31.4
Total cost of transportation from Saint Louis to New York	34.0
Loss by lakes and canal route	2.6

SECOND STATEMENT.

This statement relates to the transportation of grain from Chicago to Liverpool, and from Saint Louis to Liverpool.

	Cents.
Average freight-charges from Chicago to Liverpool via New York	45.8
Average freight-charges from Saint Louis to Liverpool via New Orleans	40.9
Loss from Saint Louis to Liverpool	4.9

Adding the transfer-charges and marine insurance we obtain the total cost of transportation, as follows:

	Cents.
Total cost of transportation from Chicago to Liverpool via New York	53.7
Total cost of transportation from Saint Louis to Liverpool via New Orleans	47.3
Loss from Saint Louis to Liverpool	6.4

These were the average charges in 1872, and they, of course, refer to the Mississippi River in its unimproved condition; but, as the project now under consideration necessarily includes the improvement of that river to a minimum depth of from 8 to 10 feet, at all stages, below Saint Louis, we may assume that the rate of freight from Saint Louis to New Orleans will be then only $7\frac{1}{2}$ cents a bushel, with a fair margin for profit on the part of the barge-owners, as shown by the evidence of the superintendent of the Mississippi Transportation Company, and the Senate committee came to the conclusion that the charges might be reduced below $7\frac{1}{2}$ cents ($\frac{6}{100}$ mill per mile) and yet leave a liberal return for the capital invested.

The length of the coast route from New Orleans to Saint Mark's is 394 miles, more or less. From Saint Mark's to Saint Mary's the distance by the previously-assumed route is 226 miles; or, equating for 20 locks at $1\frac{1}{2}$ miles per lock, 256 miles, making the total from New Orleans to Saint Mary's 650 miles. The Mississippi route from Saint Louis to New Orleans is 1,250 miles. The total length of the route from Saint Louis to Saint Mary's (all barge or steamboat route of 1,500 tons cargo capacity)

would therefore be 1,900 miles. Supposing that goods can be transported from New Orleans to Saint Mary's at about the same rate as on the Mississippi, which does not seem unreasonable, considering the small amount of lockage to be overcome on the Okefenokee level, the actual freight from Saint Louis to Saint Mary's would amount to 11.4 cents; or, allowing 1.6 cents for lockage, 13 cents per bushel.

On the route from Chicago to New York the charges for transfer and insurance were, in 1872, equal to 4.8 cents. If we put the charge for this item at 5 cents, the total cost of transportation from Saint Louis to Saint Mary's will be 18 cents a bushel.

If we add to this the cost of the article at Saint Louis we shall obtain the market price at Saint Mary's, and there seems to be no reasonable doubt that it will be considerably lower than the average price in the South Atlantic States.

The average value of a bushel of wheat in 1874 was estimated at $1.35 in South Carolina and $1.53 in Georgia, while in Missouri, in the same year, it was 83 cents.

It is even within the range of possibility that grain could be shipped profitably from Saint Mary's to New York, when it is considered that at 5 cents a bushel it will pay to carry grain from Chicago to Buffalo by lake-vessels—a distance considerably greater than that from Saint Mary's to New York.

In the evidence taken before the Senate committee, Mr. Henry C. Haarstick, vice-president of the Mississippi Valley Transportation Company, said: "I think if we had 22 feet or 24 feet of water at the mouth of the Mississippi River we could send wheat to New York, and compete with other routes." Now, by prolonging the Mississippi, as it were, by means of the Florida route, and finding a good harbor on the Atlantic coast, this condition is not only fulfilled, but the delays and dangers of the Florida channel are avoided, with a saving in time, insurance, wear and tear of vessels and machinery, wages of crew, &c., which will probably more than compensate for the additional length of the barge-route.

Considering either Saint Mary's or Brunswick, Georgia, as places for exporting grain to Liverpool, their distances from the latter place are (by actual calculation) 4,097 and 4,076 statute miles, respectively, while the distance between New York and Liverpool is 3,320 statute miles—a difference of 777 miles in favor of New York as against Saint Mary's. The average price of freight from New York to Liverpool, in 1872, was 19.2 cents per bushel; at that rate, from Saint Mary's to Liverpool it would be 23.7 cents. The transfer-charges, marine-insurance, &c., amounted in New York to 3.1 cents. For Saint Mary's, allowing somewhat larger insurance on account of the longer trip, these charges may be put down at 4 cents a bushel, We can make, therefore, the following comparative statement:

	Cents.	
Transportation Chicago to New York	31.4	
Transfer-charges and insurance in New York	3.1	
Freight to Liverpool	19.2	
		53.7
Transportation Saint Louis to Saint Mary's	18.0	
Transfer-charges and insurance at Saint Mary's	4.0	
Freight to Liverpool	23.7	
		45.7
Difference in favor of Saint Mary's		8

In the foregoing comparison the freight-rates of the year 1872 have been used. Since then the through-charges on the northern route have

been lower—considerably so within the last two years—under the influence of a general depression in all branches of business that cannot continue for any length of time.

There seems little room to doubt that breadstuffs can be carried to Liverpool, and possibly to New York, at lower rates by way of the Mississippi, even in its unimproved condition, than by the northern lakes and New York canals, and one reason why a larger quantity of grain has not, of late years, sought the cheaper route is that the civil war crippled and paralyzed the South, and capital, unable to find safe employment at New Orleans, sought the ports of the North, where new channels were opened and old channels enlarged and improved. Another, and perhaps the most potent, cause why capital is not more readily invested in commercial enterprises by the New Orleans route is the element of uncertainty caused by the obstructions at the mouth of the Mississippi, by which vessels are frequently detained for hours, days, and even months. These uncertainties sufficiently account for the fact that western produce shuns so dangerous and difficult a passage, and that capital seeks more reliable channels.

With the Florida canal finished, and, say, Brunswick selected as the eastern terminus, there will be a harbor with a reliable depth over the bar of 17 feet at mean low-water and nearly 24 feet at mean high-water, enabling vessels drawing 22 to 23 feet to cross in safety.

It is known that this bar has preserved its depth uniformly for a great number of years, and that the ship-channel over it has not materially changed in position or direction, showing it to be in a normal condition of equilibrium.

The inner anchorage is of great capacity, is quickly reached, and entirely protected from storms. It may also be stated that this is susceptible of complete defense by fortifications and their accessories.

In the important matter of cost of construction, although not necessarily embraced in this preliminary report, it seems proper to state that the Florida barge-canal undoubtedly possesses a great advantage over even the cheapest of the other routes named. With a freight-carrying capacity twice as great as that of the contemplated route between the Tennessee and the Altamaha Rivers, its construction, including those of the inside terminal connections west to the Mississippi River and north to Brunswick, would, it is believed, cost very considerably less. In addition to this, its total lockage up and down will not exceed 256 feet, while that of the Tennessee and Altamaha line is stated by Major McFarland to be 1,969 feet, indicating very important differences in favor of the Florida route, in respect not only to the original outlay for construction, but also to the current expense of administration, maintenance, and repairs, as well as the delays and charges for lockage.

With single locks, and allowing 30 minutes for lockage, the canal will have a yearly freight-carrying capacity each way of more than 13,000,000 tons, which may, of course, be doubled by doubling the locks. As there will not be more than 25 locks, at the outside, and perhaps not more than 20, the cost of duplicating them will be comparatively small.

It may be stated that the advantages which a Florida barge-line of the capacity above indicated would possess over one of smaller dimensions need not necessarily be taken for granted.

The possibilities of this route become still more promising if we regard as accomplished the entire improvement of the Mississippi River, beyond Saint Anthony's Falls in Minnesota, when wheat and corn can be transported from Minnesota, Iowa, Wisconsin, Illinois, Indiana, Missouri, and other States above Cairo, to New Orleans, for an average of

12 cents per bushel, and from Saint Paul for 17 cents. Adding 5½ cents to the latter figure for transportation from New Orleans to Saint Mary's, and it will be seen that at a cost of 22½ cents per bushel for freight and other charges, grain may be sent from Saint Paul to Saint Mary's, and by further adding 27.7 for shipping to Liverpool, the aggregate cost of transporting grain from Saint Paul to Liverpool via Saint Mary's will average 50.2 cents per bushel, while in 1872 the cost from Saint Paul to Liverpool, including transfer and terminal charges at Chicago, Buffalo, and New York, averaged 67.5 cents per bushel, a difference of 17.3 cents per bushel in favor of the Mississippi and Florida route.

The beneficial effects of bringing cheap breadstuffs to the doors of the cotton States are set forth in the following remarks contained in the report of the Senate committee:

> The development of southern markets for the grain of the Northwest is believed to be a subject of very great commercial importance. The States of South Carolina, Georgia, Alabama, Tennessee, Mississippi, Arkansas, Louisiana, and Texas constitute, beyond doubt, the largest and most valuable cotton-growing area on the surface of the globe. The soil and climate of a large part of these States are, however, unfavorable to the profitable culture of cereals. The States of Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Nebraska, Missouri, and Kansas, on the other hand, embrace the most extensive, and by far the richest, grain-producing area in the world. Owing to the cost of transport of the cereals of the West to the South-Atlantic and Gulf States, the demand for breadstuffs causes thousands of acres of land to be diverted to the unprofitable culture of wheat and corn where cotton might be more profitably cultivated if cheap breadstuffs could be procured elsewhere. With cheap and direct transportation provided between the grain States and the cotton States, the interests both of the producers of cotton and of grain would be subserved.

The Mississippi and Florida route gains still more importance when it is observed that already the extreme Northwestern States and Territories east of the Rocky Mountains, such as Dakota, Montana, Wyoming, and Colorado, are beginning to develop their resources as wheat-growing countries. For those remote regions the pressing necessity of providing a cheap outlet for their surplus produce is obvious. An inspection of the map shows that the system of rivers by which these States and Territories are drained indicates that the most natural outlet will be by way of the Missouri and Mississippi Rivers, with Saint Louis as the chief receiving and distributing depot.

By the Mississippi and Florida route the most distant northwestern portions of the Union east of the Rocky Mountains will be brought into the cheapest possible commercial communication with the extreme Southeastern States, thus affording the most desirable facilities for interchanging the produce peculiar to their respective sections, and mutually promoting the material interests of both.

By means of this route the entire Mississippi basin, through its great tributaries, the Missouri, Platte, Illinois, Ohio, Arkansas, and Red Rivers, and their navigable feeders, will be enabled to send in river steamers and barges its surplus produce of every description to the Atlantic coast in unbroken bulk. The cargoes would be carried in some cases upward of 3,500 miles. Nor will this immense basin represent all the area that will furnish trade to this line, since large portions of Alabama, Mississippi, and Georgia, with their independent systems of rivers, when sufficiently improved, will likewise assist in increasing the tonnage of the route. Indeed, the demand upon this line promises to be so great under that invariable law of trade by which an article for sale always seeks the cheapest method of reaching a good market, that it would be necessary to exact only the most moderate tonnage-dues to render its construction, administration, and maintenance a very light

burden for the General Government to carry, while a larger portion of the people of the country would be reached by its benefits than by any of the other routes that have been discussed.

Some apprehensions were formerly entertained in regard to the injurious effects of the southern climate upon the cereals sent from the Northwest into the Gulf States.

This matter may be considered as having been disposed of by the investigations of the Senate committee, which led them to express the opinion that "little, if any, greater difficulty need be apprehended by this (the Mississippi) route than by any other. This opinion is borne out by the fact that wheat shipped from San Francisco to Liverpool, passing the equator twice, and doubling Cape Horn, is said to have always arrived there in first class condition."

No discussion of the special advantages which the ship-canal might be supposed to possess over the barge-line will be attempted.

THE DANGERS OF THE FLORIDA PASS.

Another source of tonnage on the Florida line will be the coastwise trade of the United States, which will undoubtedly take advantage of this convenient mode of making the transit from the Atlantic Ocean to the Gulf, or *vice versa.* A numerous class of light-draught coasters, whether propelled by wind or steam, plying along the coasts of the Gulf or of the Atlantic, cannot venture the risks of a passage around the Florida capes, so that the long tongue of land called Florida actually acts as a barrier to the full development of the coastwise trade. While it is true that numbers of coasters that might be accommodated by the canal will hazard the passage of the Florida straits, it is no less true that so many are the shipwrecks on the southern and southeastern coast of that State that its inhabitants consider wrecking as one of their regular, as it is one of their most thriving, industries. According to the Official Guide of Florida for 1873, there were, during that year, 700 salvage cases decided by the salvage court of Key West, which is the principal rendezvous of the wreckers along the Florida reefs east of that point. The Official Statistical Register of Alabama for 1871 says:

> Rather than risk the dangers of the Florida Pass, shippers in Mobile now prefer 160 miles of rail from Cedar Keys to Fernandina, in Florida, with a delay of several days, and all the expenses, losses, and inconveniences involved in two transshipments, one from ship to rail, the other from rail to ship.

Lieut. M. F. Maury, in his report on the Florida Pass, expresses the opinion that—

> Rather than incur the risks of that dangerous navigation, four times the equivalent of railway transportation, with the delays and expenses of two transshipments, were preferred *across* the peninsula.

It is a well-known fact that much of the cotton which formerly and necessarily sought shipment at Mobile now goes to Savannah, Ga., by rail from Montgomery, Selma, and other local centers of the cotton trade.

From the most trustworthy information available on this subject, it appears that the extra insurance on vessels passing through the Florida straits amounts to nearly $3,000,000 annually, and the annual losses to more than $2,000,000. Some authorities place it as high as $2,500,000.

In order to find how much tonnage might accrue to a Florida canal through the present coastwise trade, it was thought desirable to ascertain the number of vessels, and their tonnage, entering and clearing

Gulf ports during the year, and passing through the Florida channel; but the inquiries made for that purpose at the customs districts of the Gulf, and at the Government Bureau of Statistics, have been responded to very incompletely, and the information received entirely fails to furnish data for determining the aggregate amount of tonnage and value of the coastwise trade that way. There seems to be a defect in legislation with respect to the coastwise movement of vessels of the United States, which prevents the collection of full statistics on the subject, to which attention has been repeatedly drawn in the reports of the Chief of the Bureau of Statistics. It has been deemed best not to introduce the incomplete information that has been supplied in this connection.

A SURVEY TO DETERMINE THE FEASIBILITY, ETC., OF THE PROJECT.

An examination sufficiently in detail to determine the feasibility of the project, with a general estimate of its cost, should embrace the following points:

A survey of Okefenokee basin to determine its water-capacity, and the best method of draining it; the selection of the approximate location of the summit-level and feeder, and the positions of the locks; repeated barometric observations along the summit-line to ascertain its approximate altitude; the gauging of streams that may form a part of the route, and the character, magnitude, location, and number of obstructions therein; the gauging of tributaries to those streams; the determination of the number, location, and extent, and the general hydraulic capacity of swamps and ponds that may be traversed by the line; the determination of the best general location of the western branch between the Suwannee River and Saint Mark's, and the collection of all information having any bearing upon the subject that can be obtained from river and branch pilots, and the inhabitants of the country.

Estimated cost of examination $7,500

A SURVEY FOR A DETAILED PROJECT AND ESTIMATE.

If it were desired to complete the whole survey in four working months it is thought that eight working parties of six to eight men each, costing from $500 to $600 per month for each party, could accomplish it in that time.

These parties might be placed as follows:

On the Saint Mary's River	1 party.
On the summit-level and Okefenokee Swamp	3 parties.
On the Suwannee River	1 party.
Between the Suwannee River and Saint Mark's	3 parties.

The total pay of the eight parties would be equal to the pay of one party for thirty-two months. The total cost of such a survey would be, therefore, including the purchase of instruments, stationery, camp equipage, &c.:

32 months' pay of one party at $500 or $600 per month	$16,000 to	$19,200
Instruments, and field and office stationery		3,200
Camp equipage		1,000
Boat and wagon hire		3,000
Boring or shaft-sinking		2,000
Traveling expenses		1,600
Office work		2,500
Ten per cent. contingencies	2,930 to	3,250
Total	$32,230 to	$35,750

If the preliminary examination to determine the feasibility of the route be made first, as already indicated, the foregoing estimate of the cost of a detailed survey may be reduced $3,000 or $4,000.

Very respectfully, your obedient servant,

Q. A. GILLMORE,
Lieut. Col. of Engineers, Bvt. Maj. Genl., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A.

TABLE I.—*Showing the relative amounts of cereals generally, (comprising wheat, corn, rye oats, and barley,) as well as of wheat and corn, raised in the "grain States," and in the balance of the United States. Also, the amount of grain, and of wheat and corn only, in bushels, per head of population, raised in either section of country, and in the United States, and the ratio of increase or decrease in population and crops of grain, and of wheat and corn only, from* 1850 *to* 1874.

Year.	Where grown.	Percentage of crops; crops of United States =100.			Amount in bushels raised per head of population.			Increase or decrease (percentage) as compared with next preceding year in table.							
								Population.		Cereals.		Wheat.		Corn.	
		Cereals.	Wheat.	Corn.	Cereals.	Wheat.	Corn.	Increase.	Decrease.	Increase.	Decrease.	Increase.	Decrease.	Increase.	Decrease.
*1850	Grain States	36.12	43.6	37.6	57.4	8.1	41.2	..	....	....	....	....	....	....	....
	Balance of United States.	64.88	56.4	62.4	30.8	3.2	20.8	....	....	....	....	....	....	....	....
	United States	100.00	100.00	100.00	37.0	4.3	25.5	....	....	....	....	....	....	....	....
†1860	Grain States	46.9	54.9	48.4	63.0	10.45	44.7	68.	....	85.	....	116.7	....	82.8	....
	Balance of United States.	53.1	45.1	51.6	29.0	3.49	19.1	25.7	....	18.2	....	37.9	....	17.0	....
	United States	100.00	100.00	100.00	38.9	5.5	26.7	35.5	....	42.3	....	72.3	....	41.6	....
1870	Grain States	58.8	68.00	60.4	62.5	15.	33.86	42.0	....	41.4	....	105.	....	8.12	....
	Balance of United States.	41.2	32.00	39.6	22.13	3.24	12.57	14.5	....	....	12.6	19.	....	....	25.6
	United States	100.00	100.00	100.00	35.7	7.46	19.74	22.0	....	12.8	....	66.2	....	....	9.3
‡1872	Grain States	58.1	62.5	63.5	74.9	10.64	50.5	6.	....	27.	....	....	19.8	57.9	....
	Balance of United States.	41.9	37.5	36.5	23.9	3.57	15.2	2.6	....	10.0	....	0.8	....	24.	....
	United States	100.00	100.00	100.00	41.4	6.25	27.3	3.7	....	20.2	....	....	13.8	43.6	....
1874	Grain States	60.00	64.4	60.4	60.0	13.7	35.4	5.5	....	....	15.7	27.5	....	....	2.6
	Balance of United States.	40.00	35.6	39.6	21.4	4.04	12.5	2.5	....	....	7.7	16.4	....	....	15.7
	United States	100.00	100.00	100.00	34.8	7.42	20.5	3.7	....	....	12.7	25.7	....	....	22.1

* Eight "grain States" only; Kansas and Nebraska not yet admitted.

† Ten "grain States" in this and the following years, viz: Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, Kansas, and Nebraska.

‡ Population in 1872 and 1874 computed from census returns for 1840, 1850, 1860, and 1870.

TABLE II.—*Population and grain production of United States in the years* 1850, 1860, 1870, 1872, *and* 1874.

Year.		Wheat.	Corn.	Rye.	Oats.	Barley.	Total grain.	Population.
1850	Ten grain States	43, 842, 038	222, 208, 502	839, 443	42, 348, 731	831, 517	310, 070, 231	5, 403, 563
	Balance of United States	56, 643, 906	369, 862, 602	13, 349, 370	104, 235, 448	4, 335, 498	548, 426, 824	17, 788, 313
	United States	100, 485, 944	592, 071, 104	14, 188, 813	146, 584, 179	5, 167, 015	858, 497, 055	23, 191, 876
1860	Ten grain States	95, 004, 185	406, 146, 464	4, 105, 158	62, 950, 678	4, 908, 723	573, 115, 208	9, 091, 879
	Balance of United States	78, 100, 739	432, 646, 278	16, 996, 222	109, 692, 507	10, 917, 175	648, 352, 921	22, 351, 442
	United States	173, 104, 924	838, 792, 742	21, 101, 380	172, 643, 185	15, 825, 898	1, 221, 468, 129	31, 443, 321
1870	Ten grain States	194, 763, 878	439, 111, 805	6, 472, 904	159, 690, 494	10, 608, 389	810, 647, 470	12, 966, 930
	Balance of United States	92, 981, 748	321, 832, 744	10, 445, 891	122, 416, 663	19, 152, 916	566, 829, 962	25, 591, 441
	United States	287, 745, 626	760, 944, 549	16, 918, 795	282, 107, 157	29, 761, 305	1, 377, 477, 432	38, 558, 371
1872	Ten grain States	156, 228, 000	693, 625, 000	5, 563, 300	163, 479, 000	10, 092, 000	1, 028, 987, 100	13, 740, 000
	Balance of United States	93, 769, 100	399, 094, 000	9, 325, 300	108, 268, 000	16, 754, 000	627, 210, 800	26, 260, 000
	United States	249, 997, 100	1, 092, 719, 000	14, 888, 600	271, 747, 000	26, 846, 000	1, 656, 198, 100	40, 000, 000
1874	Ten grain States	198, 928, 000	513, 688, 000	5, 680, 000	137, 430, 000	12, 082, 000	867, 808, 000	14, 500, 000
	Balance of United States	109, 165, 700	337, 042, 000	9, 310, 900	102, 938, 000	20, 470, 100	578, 926, 700	27, 000, 000
	United States	308, 093, 700	850, 730, 000	14, 990, 900	240, 368, 000	32, 552, 100	1, 446, 734, 700	41, 500, 000

NOTE.—The ten "grain States" comprise Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, Kansas, and Nebraska. The population in the years 1850, 1860, and 1870, is obtained from the United States Census Reports; that for the years 1872 and 1874 has been estimated.

APPENDIX I.

ANNUAL REPORT OF CAPTAIN A. N. DAMRELL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1877.

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., July 17, 1877.

GENERAL: I have the honor of transmitting herewith annual reports, with financial statements, for the year 1876–'77, for the river and harbor improvements under my charge.

Very respectfully, your obedient servant,

A. N. DAMRELL,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

I 1.

IMPROVING HARBOR AT MOBILE, ALABAMA.

During the last fiscal year, the opening of a channel 200 feet wide, 13 feet deep at mean low-water, had been accomplished, and, in order to complete this improvement in accordance with approved plans and instructions, the only work remaining to be executed at the beginning of this fiscal year was the completion of the widening of the channel through Choctaw Pass to a width of 300 feet.

This work was carried on under an unexpired contract with S. N. Kimball, and an unexpended balance of an appropriation of $26,000, made by act of Congress approved March 3, 1875.

In September, 1876, the widening of this channel from 200 to 300 feet being accomplished, work was suspended, and during the remainder of the year operations were confined to the care and preservation of the property pertaining to this improvement.

The amount of material excavated during this fiscal year is as follows:

	Cubic yards.
July, 1876, Choctaw Pass	20,092
August, 1876, Choctaw Pass	20,824
September, 1876, Choctaw Pass	5,217
Total	46,133

By the completion of Choctaw Pass Channel the object of this improvement, "to open a 13-foot channel from Mobile River to the 13-foot curve in Mobile Bay," has been attained. Since its completion in September last no changes in the depth of water have been reported, and the records of the pilots show that during the year 99 barks, brigs, and

schooners, drawing from 9 to 13 feet of water, have passed in and out through this channel.

The following is a statement of the number of cubic yards excavated and amounts expended each year, from the beginning of the work, on this improvement:

Fiscal year.	Cubic yards excavated.	Amount expended.	Fiscal year.	Cubic yards excavated.	Amount expended.
1870-'71	38,500	$20,714 76	1875-'76	220,575	$55,171 56
1871-'72	107,963	58,705 39	1876-'77	46,133	12,250 26
1872-'73	163,269	61,106 29			
1873-'74	373,389	96,945 35	Grand total	1,303,581	390,169 55
1874-'75	353,752	85,275 94			

After deducting amounts expended in removing wreck and jetties, the average cost per cubic yard of dredging is 28 cents, including all engineering, office, and incidental expenses.

The original estimate of the total cost, made in 1870, was $656,800, but assumed a width of channel of 300 feet the whole length. This was revised, later, the same year, and estimated at $774,315.52, with an assumed width of 250 feet over Dog River Bar, and 200 feet for Choctaw Pass. It was again revised in 1873, and the cost put at $589,237.69, with a width of channel of 200 feet the whole length. The channel, as actually cut, has a width of 300 feet through Choctaw Pass, and 200 feet through Dog River bar, and cost (including $70,550 expended by the Alabama State Harbor Board, exclusive of removing obstructions,) $460,719.55.

The great reduction of the actual below the estimated cost is due to the fact that the greater part of the dredging was done at contract prices, much below those upon which the estimate was based and those proposed in the earlier bids.

The improvement, so successfully accomplished, has been of great benefit to the commerce seeking this port, but a large class of vessels which cross the outer bar, which has a mean low-water depth of 21 feet, are still compelled to lie at anchor about 27 miles from the city, and discharge and receive their cargoes by lightering, with all the disadvantage of increased freight and liability to damage of merchandise transferred in this way.

Such an improvement of the bay of Mobile as would admit of all vessels crossing the outer bar and entering the harbor, sailing up to the wharves of the city, is an important one, one much desired by all interested in commerce at this place, and one, in my opinion, easily attained at a reasonable expenditure compared with commercial importance of the harbor, present and prospective, and I would therefore recommend that an appropriation of $10,000 be made to commence the work, according to such plans as may be decided upon by a Board of Engineers to be convened for the purpose, the cost of the necessary examination and survey to obtain the necessary data for the use of the Board to be paid from this appropriation.

As a conclusion to this report, I deem it my duty to report that a company called the Mobile Bay Breakwater Company has, under charter and authority from the legislature of the State of Alabama, already commenced work on a breakwater on the Middle Ground, to the north of Mobile Point, of which the proposed location and extent are about as follows, as reported by their engineer:

The main line or northwestern face of the breakwater to conform to the general direction of the southeast edge of the Middle Ground, that is, along the 18-foot curve,

as near as practicable, extending as far eastward as the extent of deep water, and thence by an angle to a southeast course, and extend in a direction toward the spit (off Navy Cove) as far as may be necessary for the proper protection of the proposed harbor. The westward extension of the breakwater is to be to a point in the 18-foot curve near the southwest end of the Middle Ground, and bearing about due north from the wharf at Fort Morgan, Mobile Point, from which point the west wing to extend in about a due south course toward the wharf, and in that direction till a front in 24 feet of water is reached, giving an entire length of breakwater, including main line and wings, of about 2 miles.

The effect of this construction cannot be positively fixed by data at present available, and no satisfactory report can be made, should one be called for, as I suppose is probable, (the company having memorialized Congress to indorse the plan,) until after long-continued and careful examination of the currents in that portion of the bay.

I think, therefore, if any appropriation is made for Mobile Bay, the act should be so worded as to allow of a portion of it being used in the examination above referred to.

This work is in the collection-district of Mobile, Ala., and Mobile is the port of entry.

The following statistics have been furnished me by the collector for the fiscal year: Number of vessels entered, 238, with a tonnage of 110,346 tons; number of vessels cleared, 213, with a tonnage of 110,714 tons.

Value of exports of domestic produce, $12,812,066; value of imports, $648,404.

Appropriation asked for fiscal year ending June 30, 1879, $10,000.

Money statement.

July 1, 1876, amount available	$16,265 83
July 1, 1877, amount expended during fiscal year	12,250 26
July 1, 1877, amount available	4,015 57
Amount that can be profitably expended in fiscal year ending June 30, 1879.	10,000 00

I 2.

REMOVAL OF OBSTRUCTIONS AT THE ENTRANCE TO THE HARBOR OF PENSACOLA, FLORIDA.

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., December 19, 1876.

GENERAL: In compliance with instructions contained in circular-letter of the 3d of November, 1876, I have the honor to submit the following statements in regard to "an examination and survey to ascertain the cost and practicability of removing the obstructions at the entrance of the harbor of Pensacola, Fla."

At the entrance to this harbor there are four wrecks, as follows:

No. 1. Pilot-boat Nettle, 34 tons, sunk May 31, 1875, in 4½ fathoms of water, about 1 mile north-northeast of the Outer Bar Buoy.

No. 2. Ship William Miles, 1,200 tons, wrecked in the year 1869 in 12 feet of water, on the Middle Ground, about three-fourths of a mile east of Fort McRee, now buried in the sand.

No. 3. Spanish bark Ada, 900 tons, wrecked on No. 2 in March, 1872, and lying alongside of her.

No. 4. Steamer Convoy, burned about the year 1868, and sunk in 12 feet of water one-half mile south of the light-house, with part of her machinery still above water.

Wreck No. 1, located outside of the bar in deep water, may not prove much of an obstruction to navigation, and may not require removal.

Wrecks Nos. 2 and 3, located on the east side of the main channel, not only interfere with the navigation of light-draught vessels, but, what is of more importance, they are supposed to have an injurious effect upon the main channel. Owing to their location a strong tidal current, strongest at ebb-tide, sweeps by these wrecks and washes the sand from around them into the main channel; and since their existence this channel, according to the statements of the pilots, has shoaled 1½ feet, so that now at ordinary tides only 21 feet of water can be found. It is also supposed that they to some extent cause the rapid abrasion of the opposite shore at Fort McRee.

Wreck No. 4, being partly out of water and plainly visible, may not be very objectionable to navigation, but should it be found to exert any injurious influence upon the direction of the tidal current its removal would become necessary.

The harbor of Pensacola, Fla., is undoubtedly the finest harbor on the Gulf of Mexico. It covers an area of over 20 square miles, with ample depth and good anchorage-ground; is perfectly landlocked and easy of access. Pensacola is the port of entry. The commerce of this port consists almost exclusively in the exportation of timber and lumber, principally to foreign countries, and is mostly carried on in vessels of heavy draught. The following is an average, obtained from statistical figures of the last three years, furnished me by the collector of this port:

Value of imports	$23,067
Value of exports	$2,068,767
Number of vessels entered	590
With tonnage of	233,009
Number of vessels cleared	579
With tonnage of	234,263

In this harbor is also located a United States navy-yard, the only one on the Gulf of Mexico; and this fact alone would make the preservation of a deep channel through its entrance a work of national importance.

The probable expense attending the examination and location of these wrecks with necessary soundings and current-observations sufficient to determine the necessity and feasibility of their removal, with general estimate of cost thereof, will be about $4,000.

* * * * * * *

Very respectfully, your obedient servant,

A. N. DAMRELL,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A.

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., May 29, 1877.

SIR: The attention of this office has again been called to the importance of an examination to ascertain the cost of removing the wrecks in the entrance to Pensacola Harbor. The estimate of $4,000 you sub-

mitted for this purpose, in your letter of December 19, last, is deemed excessive, and, besides, that amount cannot be spared from the very limited funds at disposal for that purpose. It is thought that a sufficient examination can be made for a much less sum, especially as you say the Coast-Survey charts will furnish much of the data and no survey will be necessary.

You will please, therefore, revise your estimate, and ascertain the smallest cost of such an examination as will furnish, if not an absolute, at least a close, approximation to the cost of removal.

By command of Brigadier-General Humphreys.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Major of Engineers.

Captain A. N. DAMRELL,
Corps of Engineers, U. S. A.

LETTER OF CAPTAIN A. N. DAMRELL, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., June 2, 1877.

GENERAL: In reply to department letter of the 29th ultimo, I have the honor of submitting an estimate of cost of an examination for furnishing an approximate estimate of cost of removal of the four wrecks at the entrance of Pensacola Harbor:

Charter of schooner for one month	$300 00
Diving apparatus, diver and assistant, one month, at $20 per day	600 00
Assistant engineer in charge, one month	150 00
Tools, rope, &c	200 00
Contingencies	250 00
	1 500 00

Very respectfully, your obedient servant,

A. N. DAMRELL,
Captain of Engineers,

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

LETTER OF CAPTAIN A. N. DAMRELL, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Mobile, Ala., July 24, 1877.

GENERAL: As promised in my letter of June 23, 1877, I have the honor of reporting that the cost of removing the four wrecks specified in Pensacola Bay is approximately estimated by me at $20,000 for the whole, and I would recommend an appropriation of this amount for the improvement of Pensacola Harbor.

As there were some inaccuracies regarding these wrecks in my letters of December 19, 1876, and June 23, 1877, I here give the list corrected according to my present information:

Class.	Name.	Tonnage.	Date of wreck.	Depth of water.	Remarks.
				Feet.	
Ship	Wm. Miles....	1,200	1869	12	Iron fastened; well settled in the sand; considerably broken up; no value.
Bark	Ada	700	1872	13	Iron and copper fastened; well settled in the sand; not much value.
Steamer	Convoy........	375	1864	12	Iron and copper fastened; well buried in the sand.
Pilot-boat....	Nettle.........	34	1875	14	Outside well settled in the sand.

The positions are as stated heretofore.

Very respectfully, your obedient servant,

A. N. DAMRELL,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

I 3.

IMPROVING HARBOR OF CEDAR KEYS, FLORIDA.

In my report for last fiscal year on this improvement I stated that a channel 100 feet wide and 12 feet deep at mean low-water had been cut through the outer bar of this harbor. No work has been done during the present fiscal year. I am informed that this channel has been unchanged.

By act of Congress approved August 14, 1876, an appropriation of $10,000 was made for this improvement, which was made available by order of the honorable the Secretary of War, dated March 3, 1877, authorizing its expenditure. In reply to letter from the Chief of Engineers, dated March 3, 1877, asking for the recommendation of a project for the expenditure of this appropriation, it was proposed to apply the same—

1st. To widen the cut through the outer bar to a width of 150 feet, by dredging, under contract.

2d. To widening and deepening the channel inside Sea-Horse Key, by dredging, under contract.

By letter of the Chief of Engineers, dated March 17, 1877, this project was approved, and, under date of April 7, 1877, advertisements for proposals for this work were published under authority of the honorable the Secretary of War. On May 22, 1877, four bids were received and opened, and abstract of same forwarded to the Chief of Engineers May 23, 1877. By letter dated June 1, 1877, the contract for this work was awarded to the lowest bidder, Jas. E. Slaughter, at 59½ cents per cubic yard for inside dredging, and 92 cents per cubic yard for dredging on the outer bar.

Work on this improvement will be commenced as soon as the contractor can put his dredge-boat in working order.

This work is located in the collection-district of Saint Mark's, and Cedar Keys is the port of entry.

No statement of the commerce of this port has been furnished by the collector, although timely application was made from this office, but will be forwarded as soon as received.

Original estimated cost of this work	$133,500
Whole amount appropriated..	32,500
Appropriation asked for fiscal year ending June 30, 1879..................	50,000

Abstract of bids is herewith attached.

Money statement.

July 1, 1876, amount available	$4 95	
Amount appropriated by act approved August 14, 1876	$10,000 00	
		$10,004 95
July 1, 1877, amount expended during fiscal year		21 30
July 1, 1877, amount available		9,983 65
Amount (estimated) required for completion of existing project		101,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		50,000 00

Abstract of bids received and opened May 22, 1877.

	Nature of work.	Name of bidder.	Amount bid for.	Price per cubic yard, inside work.	Price per cubic yard, outside work.	Time of commencing work.	Time of completing work.
1	Dredging in the harbor of Cedar Keys, Fla.	Jas. E. Slaughter	10,000 cubic yards, more or less.	$0 59½	$0 92	On or before September 1, 1877.	On or before November 30, 1877.
2	Dredging in the harbor of Cedar Keys, Fla.	S. N. Kimball	....do	64	94	On or before August 31, 1877.	On or before December 31, 1877.
3	Dredging in the harbor of Cedar Keys, Fla.	Chas. Fitz Simons	....do	87	97	On or before November 30, 1877.	On or before January 31, 1878.
4	Dredging in the harbor of Cedar Keys, Fla.	J. H. Gardner	....do	85	1.09	On or before July 4, 1877.	On or before November 30, 1877.

I 4.

IMPROVEMENT OF CHOCTAWHATCHEE RIVER, ALABAMA AND FLORIDA

During the month of September, 1875, operations on this river had to be suspended for want of funds, and work was not resumed until May, 1877. By Department letter, dated April 21, 1877, I was informed that, by order of the honorable the Secretary of War, the appropriation of $5,000 made by act of Congress approved August 14, 1876, for the improvement of this river was available, and instructed to submit a project for its expenditure. The recommendation that this appropriation be applied to the continuation of the work as commenced under former appropriations, and that the 3-foot channel be carried as far up the river as the funds allotted will permit, having been approved by letter of the Chief of Engineers, dated April 27, 1877, necessary preparations for the immediate commencement of operations were at once made, and during the month of May the work of removing snags, sunken logs, &c., was begun. A light-draught steamer was chartered, to work in connection with the snag-boat, in order to forward operations as much as possible during the present favorable season. One hundred and eighteen snags and stumps have been pulled out, and more than 300 overhanging trees cut and removed, to the close of the present year, leaving the lower portion, about 75 miles from the mouth of the river, in good boating condition at low-water.

During the cessation of the work, from September, 1875, to May, 1877, several land-slides occurred in the upper part of the river, which had been made navigable previously, caused principally by the lodging

of logs and timbers on the shoals, and the appropriation will only be sufficient to clear the channel of those snags, logs, and overhanging trees from the mouth of the river to Geneva.

In the upper part of the river three wrecks of steamers are still to be removed, and a channel through two rock shoals, from 200 to 300 feet long each, on which there is only about 10 inches of water, will have to be blasted before the contemplated improvement can be accomplished.

It is proposed to continue the removal of snags, cutting overhanging trees, and improvement of bars in this river during next fiscal year, until the appropriation is exhausted.

Original estimated cost of this improvement	$34,332 00
Whole amount appropriated	15,000 00
Appropriation asked for fiscal year ending June 30, 1879	19,000 00

The Choctawhatchee River is situated in the collection-districts of Pensacola and Mobile, and Pensacola, Fla., is the port of entry.

The following statement of this port has been furnished me by the collector:

Number of vessels entered during the year, 590, with a tonnage of 288,569 tons; number cleared, 587, with a tonnage of 276,724 tons; total value of exports of domestic produce, $2,276,822; amount collected on imports and tonnage dues, $51,165.60.

It is estimated that nearly one-half of the timber shipped at Pensacola comes down this river, and there is good reason to suppose the commerce on the river will be very much increased when the projected improvement is completed.

Money statement.

July 1, 1876, amount available	$284 93	
Amount appropriated by act approved August 14, 1876	5,000 00	
		$5,284 93
July 1, 1877, amount expended during fiscal year		2,498 55
July 1, 1877, amount available		2,786 38
Amount (estimated) required for completion of existing project		19,332 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		19,000 00

I 5.

IMPROVEMENT OF APALACHICOLA RIVER, FLORIDA.

No appropriation was made for this improvement for this fiscal year, and work done during the year was paid for from an unexpended balance of former appropriation.

The steam snag-boat Clara Dunning, which during the low stage of water had been employed on the Chattahoochee River, was sent to the Apalachicola River in December, 1876, and during that month and January, 1877, a large raft was removed from the junction of Moccasin Slough with Styx River, and at the junction of Apalachicola River and Moccasin Slough several large stumps were blown up and taken from the channel.

The continued rise in the river and very severe weather made a suspension of further operations necessary, and the steamer, being very much in need of repairs, was ordered to Columbus, Ga.

It is proposed to continue the improvement during next year by con-

structing a dam on the west side of the upper end of Moccasin Slough and removing the point of land on the east side, thus forcing a larger volume of water through the slough and straightening the channel.

Original estimated cost of work	$80,000 00
Amount appropriated previously	20,000 00
Appropriation asked for fiscal year ending June 30, 1879	20,000 00

This river is situated in the collection-district of Apalachicola, Fla., and Apalachicola is the port of entry.

The following statistics have been furnished me by the collector of this port:

Number of vessels entered during the year, 21, with a tonnage of 7,082 tons; number cleared, 16, with a tonnage of 228 tons. Value of domestic produce shipped by river inland, $62,250, and of merchandise imported, $200,000. Value of exports not given.

Money statement.

July 1, 1876, amount available	$8,555 50
July 1, 1877, amount expended during fiscal year	3,778 59
July 1, 1877, amount available	4,776 91
Amount (estimated) required for completion of existing project	60,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	20,000 00

I 6.

IMPROVEMENT OF CHATTAHOOCHEE AND FLINT RIVERS, GEORGIA.

Operations on this improvement were confined to the Chattahoochee River during this fiscal year.

The continued high stage of water prevented the boats from working on the bars and shoals during July, and the steam snag-boat was employed in removing snags and cutting overhanging trees until August, when work at Wolfax Bar jetty was resumed. Upon examination of the effects of the freshet on the work on this bar, it was found necessary to protect the head of the jetty by rock riprap, and to extend the breakwater on the Georgia shore to the south end of the bar, a distance of 560 feet in order to prevent further abrasion of this shore and the formation of a new bar below.

This work was completed in December, 1876, and the steamer was sent on the Apalachicola River. On her return in February, 1877, it was found that the bad condition of her hull made her unfit for further work until thoroughly repaired. She was at once ordered to Columbus, Ga., and repairs commenced without delay. A new hull had to be built, and at the close of the year all the machinery had been transferred to same, and, as soon as necessary quarters for the working party can be completed, the boat will be ready for the season's work.

The blasting-boat, with her crew and outfit, commenced operations in August, 1876, on Little Uchee Shoals, where 111 cubic yards of rock were removed, giving a 60-foot channel, 4 feet deep at low water. From this place the boat dropped down to Slick Bluff, at which place work was carried on until the middle of November, when a channel 55 feet wide and 3 feet deep had been attained. Several isolated rock reefs, very dangerous to navigation above and below this shoal, were also removed. Five hundred and eighty-two cubic yards of rock were excavated during this time. The number of blasts made was 160, the

average charge being 6 pounds of gunpowder, with 5 feet depth of drill-hole, and the actual cost of removal of rock at these shoals was $3.35 per cubic yard, including all expenses.

A rise in the river in the latter part of November prevented further blasting operations, and after the removal of 21 sunken logs from Hardridge's Shoal work was suspended for the season. In April, 1877, necessary repairs were made to the blasting-boat and tender, and operations were resumed at Middle Rock, below Slick Bluff, and, with only a few days' interruption by a rise in the river, were carried on to the close of the year. The current at this place being very strong, it became necessary to construct a breakwater above the work to procure slack-water, which, however, caused sand to settle in the eddy, retarding the progress of the work, and rendering drilling difficult. One hundred and thirty-eight cubic yards of rock were removed from the "Middle Rock" at the close of the year, requiring 89 blasts, with a charge of 6 pounds of gunpowder.

It is contemplated during next year to continue the work on the improvement of the most dangerous shoals on the Chattahoochee River, such as Hardridge's Shoals and King's Rock, and then resume operations on the Flint River.

Chattahoochee and Flint rivers are in the collection-districts of Mobile, Savannah, Brunswick, and Saint Mary's. The nearest port of entry is Apalachicola, Fla.

The following is the only information that could be obtained in regard to the statistics of the traffic carried on on these rivers:

Number of bales of cotton transported	31,730
Total value of merchandise, &c., transported	$5,796,800

Original estimated cost of improvement	$330,000
Total amount appropriated	70,000
Appropriation asked for fiscal year ending June 30, 1879	50,000

Money statement.

July 1, 1876, amount available	$27,603 06
Amount appropriated by act approved August 14, 1876	20,000 00
	47,603 06
July 1, 1877, amount expended during fiscal year	22,037 97
July 1, 1877, amount available	25,565 09
Amount (estimated) required for completion of existing project	260,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	50,000 00

I 7.

IMPROVEMENT OF BLACK WARRIOR AND TOMBIGBEE RIVERS, ALABAMA.

As soon as the stage of water permitted, a full force was engaged on this improvement, and a number of bars and shoals were made passable for boats at low water, by the construction of jetties and breakwaters, namely, Battle's Gin Bar, Washington Bar, Cut-Off Bar, White's Bar, and Cleveland Shoals. The snag-boats were engaged in removing wreck of steamer Lily and snags and sunken logs over those bars and shoals. On the 10th of August, the appropriation being exhausted, all work was suspended.

By letter from the Chief of Engineers, dated October 24, I was informed that the appropriation of $15,000, made for this improvement by act of Congress approved August 14, 1876, was available. The season being very favorable, necessary steps to resume the work were at once taken, and, on November 1, work on the jetties was resumed, and by the middle of that month a full force was employed on all the boats, and work continued until December 31, when the severity of the weather and a rise in the river compelled a cessation of active operations. During these months, November and December, 1876, the following bars were improved, viz: Bohanas, Alligator's, Colvin's Island, and Log Shoals. Several bars of less importance were passed by in order to remove, as far as possible, the most troublesome obstructions, and, by working on this plan, steamboats which had heretofore been obliged to turn back at Log Shoals were enabled, on a slight rise of the river, to extend their trips to Tuscaloosa.

The freshet in the river continued until the latter part of April, 1877, and operations on this improvement could not be resumed until May 1. The amount of funds available at this time being only sufficient to employ a small force during this working-season, it was deemed best to confine operations to the removal of snags and overhanging trees from the mouth of the river to Log Shoals, and this work has been carried on to the close of the year.

The manner of constructing jetties and shore protections, for the improvement of bars on this river, was fully described in my last report, and has been adhered to during this year's work. As the shore protections are not of a lasting character, an experiment has been made with willow-planting, and should this prove successful, many points on the river could be permanently protected in this manner.

I append, herewith, a summary of amount and kind of work done on the different bars and shoals during the past fiscal year.

Number of overhanging trees cut and removed	1,052
Number of steamboat wrecks removed	1
Number of yards of gravel dredged	400
Length of shore planted in willows	1,200 feet.

Linear feet of jetties built and number of snags removed as follows:

Localities.	Linear feet of jetties.	Number of snags removed.	Localities.	Linear feet of jetties.	Number of snags removed.
Tuscaloosa to Battle's Gin	....	110	Bar above Mary H	343	30
Battle's Gin	172	19	Colvin's Island	358	15
Washington	490	46	Log Shoals	1,340	70
Cut-Off	469	120	Jennings' Ferry	....	48
White's	333	16	Prairie Creek	....	49
Cleveland's	559	91			
Bohanas	258	30	Total	5,076	798
Alligator	754	154			

The number of bales of cotton shipped to Mobile, by the Black Warrior and Tombigbee Rivers during the fiscal year, was 60,169, and the value of the exports up these rivers is approximately valued at $2,707,605.

Original estimated cost of the work	$172,603
Whole amount appropriated	40,000
Appropriation asked for fiscal year ending June 30, 1879	100,000

The Black Warrior and Tombigbee Rivers are in the collection-district of Mobile, and Mobile Ala., is the nearest port of entry.

Money statement.

July 1, 1876, amount available	$5,118 08
Amount appropriated by act approved August 14, 1876	15,000 00
	20,118 08
July 1, 1877, amount expended during fiscal year	14,655 04
July 1, 1877, amount available	5,463 04
Amount (estimated) required for completion of existing project	132,603 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	100,000 00

APPENDIX J.

ANNUAL REPORT OF CAPTAIN C. W. HOWELL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1877.

UNITED STATES ENGINEER OFFICE,
New Orleans, La., August 6, 1877.

GENERAL: I have the honor to transmit herewith the annual reports for the fiscal year ending June 30, 1877, of the various works of river and harbor improvement and surveys under my charge.

Very respectfully, your obedient servant,

C. W. HOWELL,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

J 1.

IMPROVEMENT OF THE MOUTH OF THE MISSISSIPPI RIVER AT SOUTHWEST PASS.

The results obtained by continuance of this work during the fiscal year have been of marked benefit to commerce, and have been duly reported from month to month, as shown by the following extracts from my monthly reports:

For July:

* * * * * * *

The depth of channel at mean low tide ranged from 15½ to 16½ feet, with a least width for those depths ranging from 70 to 80 feet. High tides ranged above mean low tide from 2½ to 3 feet, making the depth of channel at high tide range from 18 to 19½ feet.

The following number of vessels crossed the bar during the month:

Steamers in	18
Steamers out	29
Sailing-vessels in	15
Sailing-vessels out	32
Total	94

Of these, 9 drew from 18 to 18½ feet. Of this number, 2, drawing 18 feet and over, were detained an aggregate of 10 hours and 45 minutes by grounding on the east side of the channel.

The above was the only detention of vessels at the Southwest Pass during the month by grounding.

Repairs to the McAlester were continued during the month and will probably be completed in August.

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For August:

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The depth of channel at mean low tide was $16\frac{1}{4}$ feet, with a least width for that depth ranging from 80 to 100 feet. High tides ranged above mean low tide from $2\frac{1}{4}$ to 3 feet, making the depth of channel at high tide range from $18\frac{3}{4}$ to $19\frac{1}{4}$ feet.

The following number of vessels crossed the bar during the month:

Steamers in	20
Steamers out	21
Sailing-vessels in	16
Sailing-vessels out	19
Total	76

Of these, 7 drew from 18 feet to 19 feet 3 inches. Of this number, 1, drawing 18 feet 10 inches, was detained an aggregate $97\frac{1}{2}$ hours by grounding on the east side of the channel. One vessel, drawing $16\frac{1}{2}$ feet, met with slight detention by grounding on outer mud lump. Repairs to the McAlester were continued during the month.

Besides the work of dredging, the Essayons was placed at the disposal of Capt. M. R. Brown for the purpose of making a survey off South Pass.

* * * * * *

For September:

* * * * * *

The depth of channel at mean low tide ranged from 16 to 17 feet, with a least width for those depths ranging from 80 to 100 feet.

High tides ranged above mean low tide from 2 to $2\frac{1}{4}$ feet, making the depth of channel at high tide range from $18\frac{1}{4}$ to $19\frac{1}{4}$ feet.

The following number of vessels crossed the bar during the month:

Steamers in	24
Steamers out	21
Sailing-vessels in	28
Sailing-vessels out	11
Total	84

Of these, 8 drew from 18 to 19 feet. Of this number, 1, drawing 18 feet 6 inches, was detained about 72 hours by grounding east of the channel. Five vessels of from 14 feet to 16 feet 6 inches draught were detained about 56 hours by grounding on the east side of the channel.

The cause of the above-mentioned vessels grounding was due to a strong easterly current, caused by strong west winds.

Repairs to the dredge-boat McAlester were continued, and will probably be completed during October.

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For October:

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The depth of channel at mean low tide was $16\frac{1}{2}$ feet, with a least width for that depth ranging from 90 to 100 feet.

High tides ranged above mean low tide from $1\frac{1}{2}$ to $2\frac{3}{4}$ feet, making the depth of channel at high tide range from 18 to $19\frac{3}{4}$ feet.

The following number of vessels crossed the bar during the month:

Steamers in	29
Steamers out	34
Sailing-vessels in	59
Sailing-vessels out	28
Total	150

Of this number, 16 drew from 18 feet to 19 feet 8 inches. Of these, 3, drawing from 18 feet to 19 feet 8 inches, were detained 33 hours by grounding on the east side of the channel. Three vessels, drawing from 15 feet to 17 feet 6 inches, were detained about 144 hours by grounding on the east and west sides of the channel.

Repairs to the dredge-boat McAlester were continued during the month, and will probably be completed early in November.

Reduction in the crews of both dredge-boats was made.

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For November:

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The depth of channel at mean low-tide ranged from 16 to $16\frac{1}{2}$ feet, with a least width for those depths ranging from 90 to 100 feet.

High tides ranged above mean low tide from 1¼ to 3 feet, making the depth of channel at high tide range from 18 to 19½ feet.

The following number of vessels crossed the bar during the month:

Steamers in	23
Steamers out	34
Sailing-vessels in	76
Sailing-vessels out	58
Total	191

Of this number, 15 drew from 18 feet to 19 feet 8 inches. Of these, 3, drawing from 18 feet 3 inches to 19 feet 8 inches, were detained 10 hours and 30 minutes in crossing the bar. Two vessels, of from 16¾ to 17¼ feet draught, were detained 23 hours and 45 minutes in crossing the bar. Repairs to the McAlester were completed during the month.

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For December:

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The depth of the channel at mean low tide ranged from 16 to 16¼ feet, with a least width for those depths ranging from 90 to 100 feet.

High tides ranged above mean low-tide from 1¾ to 2½ feet, making the depth of channel at high tide range from 17¾ to 18½ feet, with soft bottom during the month.

The following vessels crossed the bar during the month:

Steamers in	32
Steamers out	25
Sailing-vessels in	104
Sailing-vessels out	94
Total	255

Of this number, 8 drew 18 feet; 7, 18½ feet; 10, 19 feet; 3, 19½ feet; 1, 19 feet 8 inches; 1, 19 feet 9 inches; total 30, drawing 18 feet and over.

Following is a list of vessels grounding on the bar during the month, and remarks concerning same:

December 1.—Ship Atmosphere, 18 feet, was 2 hours crossing bar. Bark America, 17 feet, was 2 hours crossing bar.

December 3.—Ship Baden, 19 feet, grounded at 5 p. m. on east side of channel; got off and to sea at 9 p. m. December 5.

December 6.—Ship Martha Cobb, 16 feet 6 inches, bound out, grounded at 1 p. m. on east side of channel, below No. 4; went to sea at 6 p. m. December 9.

December 9.—Steamer Diego, 19 feet 9 inches, bound out, grounded at 5 p. m. on west side of channel, near Cleopatra Buoy; got off and to sea December 10.

December 12.—Steamer Emilano, 19 feet, bound out, grounded at 5 p. m. on west side of channel, near No. 3. She went to sea at 8 p. m. December 13.

December 15.—Ship Belgravia, 19 feet; grounded December 8 at 5 p. m.; was put to sea at 4 p. m.

December 27.—Ship Morning Star, 19 feet, grounded December 18 went to sea. Bark Granville Belle, 16 feet 6 inches, grounded at 5 p. m. 300 feet east of channel and remained all night.

The Essayons remained on duty at Southwest Pass during the month, and the McAlester was held in reserve at New Orleans.

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NEW ORLEANS, LA., *January* 24, 1877.

SIR: In view of the present rise in the river here, and the flood that is rapidly coming down from the upper tributaries, you are directed to closely watch the channel across the Southwest Pass Bar, and by working the dredge on the bar whenever and at all times when the current is favorable, and by vigilantly enforcing regulations, so far as you have the power, prevent any shoaling of channel and any blockade.

You will report condition each day by telegraph, and advise me when you think the McAlester should be sent down to assist the Essayons.

If the channel is not kept in order during this rise, and possibly deepened, I fear we shall have trouble on the bar.

You will please give this matter constant and close attention, as very much depends upon maintaining the channel.

Very respectfully, your obedient servant,

C. W. HOWELL,
Captain of Engineers, U. S. A.

Capt. C. H. ELWELL

For January:

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In consequence of the low stage of the river, and the uniformly good condition of the channel, there was no attempt at dredging made until the 29th of the month, when the channel was rapidly deepened to 17 feet, mean low tide, and widened.

The time for recommencement of dredging was opportunely chosen, as the muddy water of present rise in the river reached the bar on Thursday, the 1st of February, and on Sunday, the 4th, hard, sandy bottom began to make its appearance. The inclosed copy of report of Civil Assistant Collins, who was sent with special instructions to observe the first effect of this rise, to establish additional bench-marks at velocity stations, and to communicate certain information solicited by the assistant engineer of the South Pass Jetty Company, is submitted as of interest.

Carrollton gauge-reading to date, covering time of rise in the river, is also inclosed.

The following is a synopsis of reports received, showing commercial use of the Pass and particulars.

The depth of channel, at mean low tide, ranged from 16 to 17 feet, with a least width for those depths ranging from 60 to 100 feet. High tides ranged above mean low tide from 1¼ to 2 feet, making the depth of channel at high tide range from 17¼ to 18¾ feet.

The following vessels crossed the bar during the month:

Steamers in	25
Steamers out	33
Sailing-vessels in	49
Sailing-vessels out	108
Total	215

Of this number, 9 drew 18 feet; 1, 18 feet 4 inches; 10, 18 feet 6 inches; 4, 18 feet 9 inches; 5, 19 feet; 2, 19 feet 6 inches; total 31, drawing 18 feet and over.

Following is a list of vessels grounding on the bar during the month and remarks concerning same:

January 2.—Bark Granville Belle, 16 feet 6 inches; grounded December 27; went to sea at 5 p. m.

January 7.—Steamer Borussia, 19 feet 6 inches; grounded at 6 p. m., on east side of channel; went to sea at 2 p. m. January 9.

Ship Queen of Nations, 18 feet; grounded at 10 p. m., January 9, on west side of channel; went to sea at 4 p. m. January 15.

January 26.—Bark Tancred, 17 feet 6 inches; grounded at 10 a. m., on east side of channel; went to sea at 3 p. m.

* * * * * *

For February:

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The short rise in the river which marked the month made it necessary to work the one dredge-boat to its full capacity, and at the same time rigidly enforce regulations for use of the channel dredged.

The usual depth of channel was maintained until the top of the rise, after which the depth was slowly increased to 18 feet mean low tide, (so called, as I have heretofore explained, 2.15 feet below average flood tide South Pass.)

The depth has been increased ½ foot, and the bottom has again become soft.

The Essayons became disabled during the month from natural wear of forward shaft-casing and sleeve, and from breaking shoe and plow, and was relieved by the McAlester.

Before being placed on duty, the McAlester was sheathed fore and aft, from the light draught to the deep draught line, because of dry-rot in planking. The Essayons was brought to the city, and repairs at once commenced.

The coal-barge was also brought up for supplies, and sheathed above the light-draught line, as it was not deemed safe to load her without doing this.

Assistant Collins was engaged during the latter part of the month in surveys at Southwest Pass and Pass à l'Outre, and has not yet completed the work ordered.

The following is a synopsis of reports made by the master of the dredge-boat on duty at Southwest Pass;

Depth of channel at mean low tide ranged from 17 to 18 feet, with a least width for those depths ranging from 60 to 120 feet. High tides ranged above mean low tide from 1¾ to 2½ feet, making the depth of channel at high tide range from 18¾ to 20 feet.

The following vessels crossed the bar during the month:

Steamers in	24
Steamers out	19
Sailing-vessels in	32
Sailing-vessels out	72
Total	147

Of these, 4 drew 18 feet; 3, 18 feet 6 inches; 6, 19 feet; 1, 19 feet 6 inches; 1, 19 feet 7 inches; total 15, drawing 18 feet and over.

Following is a list of vessels grounded during the month, and remarks concerning same:

February 4.—Ship Glad Tidings, 17 feet 6 inches; grounded at 6 p. m. across channel; got off at 12.10 p. m. February 5.

February 6.—Ship Malta, 18 feet; grounded at 5 p. m., west side of channel; got off at 10 a. m. February 7.

February 17.—Bark Charles Bal, (draught not given;) grounded at 6 p. m.; got off at 9 a. m. February 18.

February 20.—Ship Belle O'Brien, 19 feet 6 inches; was two hours crossing bar.

February 21.—Steamer Texas, 19 feet 7 inches; met with slight detention.

February 25.—Bark Renown, 18 feet; was 1 hour and 25 minutes crossing bar. Ship Tirrell, 19 feet; grounded at 7 p. m. on west side of channel; got off 5.30 p. m. February 26.

February 28.—Ship Advance, 19 feet; was 3 hours crossing bar.

* * * * * * *

During the month the commercial use of South Pass in preference to Southwest Pass has been confined to a few barks coming in ballast, some schooners, and the Cromwell line of steamers, which are of medium draught, and always loaded by the stern.

Also United States man-of-war Plymouth, 17 foot-draught; Barrett, commander.

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For March:

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The work of dredging on the bar at Southwest Pass was continued as heretofore, viz, at such times as were found necessary to maintain the channel in condition to give an adequate inlet and outlet for the present commerce of this port. In this we have been successful, as shown by the following condensed statement made up from the log-book of the McAlester and from the statement following it, in which is given the depth of channel for each day of the month when soundings were taken.

DETENTION.

March 6.—Bark Energia, 17 feet 6 inches; grounded at 10 a. m., west side of channel went to sea 3.45 p. m.

March 19.—Steamer Memphis, 19 feet 10 inches; grounded at 8 a. m. on outer mud-lump; went to sea 9.05 a. m. March 20.

March 27.—Steamer Ithuriel, 17 feet 6 inches; grounded west of Cleopatra buoy at 12 m.; went to sea at 5 p. m.

March 30.—Steamer Borussia, 20 feet 6 inches; grounded at 9 a. m. on outer mud-lump; went to sea 7 a. m. March 31.

March 31.—Ship John Patten, 17 feet 6 inches; grounded at 10 a. m., west of channel; got off about 1 o'clock April 3.

The depth of channel at high tide ranged from 19½ to 20½ feet.

The channel was at all times over 18 feet in depth, with a least width for that depth of 100 feet, and the bottom soft, except on the first day of the month.

Entrances and clearances recorded:

Steamers entering	20
Steamers clearing	19
Sailing-vessels entering	25
Sailing-vessels clearing	57
Total	121

Of these, 4 drew 18 feet; 1, 18 feet 4 inches; 6, 18 feet 6 inches; 5, 19 feet; 1, 19 feet 3 inches; 1, 19 feet 6 inches; 1, 19 feet 10 inches; 1, 20 feet 6 inches; total 20, drawing 18 feet and over.

The plane of average flood-tide was ascertained by transfer from South Pass United States gauge.

Simultaneous observation was conducted at the two places for one month, and the zero at Southwest Pass, which is below all except extreme low tides, was found 2.15 feet below that at South Pass.

Assistant Collins and party completed field-work of final survey during the month; plotting is not quite finished. Repair of the Essayons is nearly finished; she will be ready for service when needed.

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For April:

* * * * * * *

The depth of channel at mean low-tide ranged from 17 to 18 feet, with a least width for those depths ranging from 60 to 100 feet. High tides ranged above mean low tide from 1½ to 3 feet, making the depth of channel at high tide range from 18½ to 20 feet.

The following vessels crossed the bar during the month:

Steamers in	1
Steamers out	12
Sailing-vessels in	41
Sailing-vessels out	54
Total	120

Of these, 2 drew 18 feet; 2, 18 feet 6 inches; 1, 18 feet 8 inches; 1, 19 feet; 2, 19 feet 6 inches; 2, 20 feet; total 10, drawing 18 feet and over.

Following is a list of vessels grounding during the month, and remarks concerning same:

April 1.—Ship Geo. Peabody, 15 feet 6 inches, grounded, in fog, on west side of channel at 6 p. m; got off at 9 a. m. April 2.

April 3.—Ship John Patten, 17 feet 6 inches, grounded May 31; got off at 10 a. m.

April 10.—Ship Warsaw, 18 feet 6 inches, grounded on outer lump at 5 p. m; got off at 3 p. m. on the 11th.

April 11.—Ship Revolving Light, 19 feet, grounded on west side of channel; got off April 17.

April 22.—Steamer Hanover, 19 feet 6 inches, grounded at 4.20 p. m. on west side of channel; got off April 25 at 10.45 a. m.

The McAlester was continued on duty at the bar during the month. Repairs to the Essayons were completed.

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For May:

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The depth of the channel at mean low tide ranged from 16 to 18 feet, with a least width for those depths ranging from 70 to 100 feet. High tides ranged above mean low tides from 1¾ to 3 feet, making the depth of channel at high tide range from 19 to 20½ feet.

Following is a list of vessels crossing the bar during the month:

Steamers in	11
Steamers out	8
Sailing-vessels in	19
Sailing-vessels out	48
Total	86

Of these, 1 drew 20 feet 5 inches; 2, 20 feet; 1, 19 feet 11 inches; 1, 19 feet 10 inches; 3, 19 feet 8 inches; 1, 19 feet 6 inches; 1, 19 feet 4 inches; 1, 19 feet 3 inches; 6, 18 feet 6 inches; 3, 18 feet; total 20 drawing 18 feet and over.

Following is a list of vessels detained, and remarks concerning same:

May 2.—Brig Onolaski, 15 feet, grounded east of channel at 12.30 p. m: got off 9 a. m. May 3.

May 8.—Ship G. Strickland, 18 feet, was 3 hours crossing bar.

May 18.—Bark Montebello, 19 feet 11 inches, grounded at 9 a. m. on west side of outer mud lump; got off May 19 at 12.40 p. m.

May 20.—Ship Arcturus, 19 feet 8 inches, grounded at 12 m. on west side of channel; got off May 26 at 7 a. m.

May 26.—Steamer Bombay, 20 feet 5 inches, grounded at 9 a. m. above Cleopatra Buoy; got off 7 a. m. May 27.

May 27.—Ship Northampton, 19 feet 10 inches, grounded at 9 a. m. on west side of channel; got off at 6.15 a. m. May 28.

May 28.—Ship Expounder, 20 feet, grounded at 7 a. m. below Cleopatra Buoy; aground May 31.

During the month the McAlester was ordered to the city for repairs to side-arm of

her deflector, and the Essayons sent to relieve her. After repairs to her deflector, the McAlester was returned to Southwest Pass for duty and the Essayons laid up at that pass.

* * * * * * *

For June:

* * * * * * *

The depth of channel at mean low tide ranged from 15 to 17 feet, with a least width for those depths ranging from 50 to 100 feet.

High tides ranged above mean low-tide from 2 to 3½ feet, making the depth of channel at high tide range from 17½ to 20½ feet.

Following is a list of vessels crossing the bar during the month:

Steamers in	12
Steamers out	13
Sailing-vessels in	19
Sailing-vessels out	31
Total	75

Of these, 3 drew 18 feet; 1, 18 feet 6 inches; 1, 19 feet; 1, 19 feet 10 inches; 3, 20 feet; 1, 20 feet 2 inches; 1, 20 feet 4 inches; 1, 20 feet 8 inches; 1, 21 feet; 1, 21 feet 2 inches. Total 14 drawing 18 feet and over.

Following is a list of vessels grounding during the month, and remarks concerning same:

June 2.—Ship Expounder, 20 feet, grounded May 28; got off.

June 4.—Ship Lancaster, 21 feet, grounded at 9 a. m.: got off at 7 a. m. June 10.

June 8.—Ship John Watt, 17 feet 8 inches, grounded at 7 a. m.; got off at 6 a. m. June 9.

June 12.—Steamer City of Havana, 15 feet 6 inches, grounded on outer mud lump; went to sea during the night.

June 15.—Bark Alfa, 19 feet, grounded at 1 p. m. on west side of channel; got off at 10 a. m. June 24.

June 24.—Steamer Chilian, 20 feet 5 inches, grounded at 6 a. m.; still aground June 30.

During the month the McAlester was brought to the city for renewal of casing to shaft, and the Essayons retained on duty at the bar.

* * * * * * *

For more detailed information than is given in these extracts, a daily record is appended in the usual form.

Of this the following synopsis is presented:

Table of dredging and its results.

Month.	No. of hours' dredging on bar.	River, (falling —; rising, +; at stand, 0.)	Number of days the channel had a depth at mean low tide as indicated below. 18' 6".	18'.	17' 6".	17'.	16' 6".	16'.	15'.	Tides ranging above mean low tide.	No. of vessels using channel.	Greatest draught of same.	No of vessels detained.
July	109.00	— and 0	......	......	......	......	17	14	......	2 to 3	92	18 6	2
August	12.00	—	......	......	......	......	31	......	......	2¼ to 3	77	19 3	1
September	7.00	— and +	......	......	......	7	19	4	......	2 to 2½	81	19 6	6
October	0.00	—, +, and —	......	......	......	......	28	3	......	1½ to 2¾	149	19 8	7
November	3.00	+ and —	......	......	......	......	24	6	......	1½ to 3	190	19 8	4
December	16.00	+, —, and —	......	......	......	......	5	26	......	1¾ to 2½	250	19 9	9
January	24.00	—, +, 0, and +	......	......	......	1	......	30	......	1½ to 2	212	19 8	3
February	210.40	+ and —	......	9	8	11	......	......	......	1½ to 2¼	147	19 7	5
March	31.25	—, 0, and +	5	26	......	......	......	......	......	1½ to 2	120	20 6	5
April	196.50	+	......	15	8	7	......	......	......	1½ to 3	121	20 0	4
May	220.50	+, —, and 0	......	8	9	6	6	2	......	1½ to 3	85	20 5	7
June	191.00	+, —, +, —, +, —, and +	......	......	......	13	12	4	*1	2 to 3¼	75	21 2	6
Total	1,021.45	......	5	58	25	45	142	89	1	......	1,599	......	59

Number of hours' detention of vessels on bar, arranged according to draught of vessel detained.

Month.	21' 2".	21'.	20' 6".	20' 5".	20'.	19' 11".	19' 10".	19' 9".	19' 8".	19' 6".	19'.	18' 10".	18' 6".	18' 3".	18'.	17' 8".	17' 6".	17'.	16' 6".	16'.	15' 6".	15'.	Less than 15'.
July	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2.05	.....	.....	16.00	.....	.....	.....
August	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	97.30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
September	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	101.00	.....	.....	.....	.....	.....	44.00	48.00	.....	.....	12.00
October	.....	.....	.....	.....	.....	.....	.....	.....	13.00	1.00	.....	.....	.....	.....	8.00	.....	172.00	.....	.....	.....	.....	4.00	.....
November	.....	.....	.....	.....	.....	.....	.....	.....	3.30	.....	.....	.....	.....	7.15	5.00	.....	.....	23.00	1.00	.....	.....	.....	.....
December	.....	.....	.....	.....	.....	.....	.....	19.00	.....	.....	455.00	.....	.....	.....	3.00	.....	.....	.....	98.00	.....	.....	.....	.....
January	.....	.....	.....	.....	.....	.....	.....	.....	.....	44.00	.....	.....	.....	.....	18.00	.....	5.00	2.00	.....	.....	.....	.....	.....
February	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	26.55	.....	.....	.....	17.00	.....	30.10	.....	.....	.....	.....	.....	.....
March	.....	.....	21.45	.....	.....	.....	25.05	.....	.....	.....	.....	.....	.....	.....	.....	.....	63.45	.....	.....	.....	.....	.....	.....
April	.....	.....	.....	.....	.....	.....	.....	.....	.....	65.35	.....	.....	163.15	.....	.....	.....	.....	.....	.....	.....	1.45	.....	.....
May	.....	.....	.....	22.00	121.40	27.40	21.45	.....	139.00	.....	.....	.....	.....	.....	3.00	.....	20.00	.....	.....	.....	.....	.....	.....
June	7.00	142.00	.....	162.00	.....	.....	.....	.....	.....	.....	213.00	.....	.....	.....	.....	23.00	.....	.....	.....	.....	.....	.....	.....
Total	7.00	142.00	21.45	184.00	121.40	27.40	46.50	19.00	155.30	110.35	694.55	97.30	264.15	7.15	54.00	23.00	313.00	25.00	143.00	64.00	1.45	4.00	12.00

* Owing to steamer Chilian being across channel.

The following statistics regarding the commerce of the port of New Orleans for the year ending June 30, 1877, have been kindly furnished from the records of the collector's office:

Statement of number and tonnage of vessels entered at and cleared from the port of New Orleans during the year ended June 30, 1877.

Entrances.			Clearances.		
No.	Class.	Tonnage.	No.	Class.	Tonnage.
403	Steam	466,088	395	Steam	467,570
730	Sail	462,564	748	Sail	396,517
1,133	Total number of vessels entered	928,652	1,143	Total number of vessels cleared	864,087

Total value of imports	$9,522,559 00
Total value of exports, domestic	70,197,732 00
Total value of exports, foreign	151,584 00
	70,349,316 00
Total amount of revenue collected on imports	1,601,646 32

The following regarding shipments of grain and cotton has been partly drawn from the columns of the New Orleans Price Current, and partly from reports made to this office from Southwest Pass:

Comparative statement of cotton and grain exported from the port of New Orleans for the years ending June 30, 1876, and June 30, 1877.

	Grain.		Cotton.
	Bushels.	*Sacks.*	*Bales.*
Year ending June 30, 1876	1,140,106[illegible]	223,350	
Year ending June 30, 1877	2,339,051[illegible]	324,859	
Excess of exports in 1877 over 1876	1,198,944[illegible]	101,509	
Year ending June 30, 1876			1,548,012
Year ending June 30, 1877			1,489,144
Decrease of exports in 1877 from 1876			58,898
1877.			
Total via Southwest Pass	1,587,433[illegible]	237,754	1,176,347
Total via other outlets	751,617[illegible]	87,105	312,797
Via Southwest Pass in excess of other outlets	835,815[illegible]	150,649	863,550

Number of vessels sailing through Southwest Pass during the year ending June 30, 1877, drawing 15 feet and over.

Draught from 15 feet to 21 feet 2 inches:	
15 feet, and under 16 feet	140
16 feet, and under 17 feet	114
17 feet, and under 18 feet	126
18 feet, and under 19 feet	114
19 feet, and under 20 feet	60
20 feet, and under 21 feet	10
21 and over	2
Total	566

These statements taken together serve to show how important it was that dredging should have been continued during the past year. Owing to frequent mistaken reports regarding available or anticipated depths of channel through the South Pass, where the experimental application of the jetty system was inprogress, many vessels were loaded to greater draughts than usual, and had it not been for the dredged channel at Southwest Pass must have suffered serious detention and loss. This must continue to be the case until after the jetty-channel may be reliably established. Even, after that, it will be advisable to hold the dredges in readiness to open a channel, should the navigation of the South Pass be impaired by the re-formation of bars at its river and Gulf ends, or by shoaling in the body of the pass, or by destruction of the jetty-works, either by storms, by the teredo, or by undermining.

DREDGE-BOATS, ETC.

The dredge-boats and other vessels employed on the work have been kept in a fair state of preservation, but owing to the possibility of suspension at some time during the year, and also because of the smallness of appropriation, which was but two-thirds of that estimated as necessary, many repairs which, in the interest of future economy, should have been made, were postponed. If found necessary to work the dredges after November next, extensive repair should be provided for.

As deterioration is rapid in this climate, the repair that will be called for cannot now be definitely specified or estimated for.

SURVEYS, ETC.

In connection with the work the following-named surveys, observations, &c., under the direction of Mr. H. C. Collins, civil assistant engineer, were made during the year:

August 28 to *September* 10, 1876.—Making deep-sea survey at Southwest Pass and South Pass.

September 11 to *September* 18.—Survey with launch out to 130 feet at Southwest Pass.

September 19 to 25.—Survey of bar at Southwest Pass.

September 29.—Survey from wreck to Snake Island, Southwest Pass.

January, 1877.—Made trip to city with launch to test for salt water in the river.

January 31.—Went to head of passes to establish some new bench-marks where the old ones were liable to be washed away.

February 2 to 4.—Made a survey of the channel at Southwest Pass.

February 15 to 19.—Made survey of Pass à l'Outre, from light to 30 feet deep outside the bar, and sounded cross-sections up Pass à l'Outre and Northeast Pass.

February 20 to 28.—Made survey of Southwest Pass out to 40-foot curve.

March 7.—Made cross-sections of the river at Cubitt's Gap, and a few soundings in Cubitt's Gap.

May 19 to 23.—Soundings in Cubitt's Gap and cross-sections of passes.

Current-measures and cross-sections:

September 28, 1876.—Current-measures on bar, Southwest Pass.

March 8 to 11, 1877.—Current-measures and cross-sections at Northeast Pass and Southwest Pass for velocity and discharge.

May 19 to 22.—Remeasured cross-sections at Southwest Pass and Northeast Pass, and made current-measures for velocity and discharge.

Mr. Collins, when not in the field, was employed in compiling and arranging the results of previous work of the same character. This has proven a greater and more delicate task than it was at first conceived to be, and while progress is being made in it, no time can be set for its satisfactory completion. The charts relating to the three main passes number 175. The separation of these into classes according to merit, locality, and extent; their consolidation into the form of comparative

charts, and the reduction of these to a scale suitable for publication, has been of itself a work requiring much time and labor.

The preparation of river, tide, and wind diagrams; the observations for velocities of current at various places and at various stages of the river; observations for volume of discharge of the river and its passes under conditions causing change, and observations for quantity of material carried in suspension by the river-water and pushed along the bottom of the passes; together with the computations and tabulations necessary to put the results in shape, have also consumed much time. Conclusions could not safely be put forth while this work was yet incomplete.

The work of survey and observation being dependent on such means as could be spared from the work of dredging, could not be pushed as it might have been under an adequate special appropriation, and my own time has been so taken up with other matters demanding attention that I have only been able at times to study the results obtained.

Some of the most important conclusions drawn from study of the data presented by these surveys and observations being of interest at the present time, I will outline. The Chief of Engineers, I believe, has been furnished the data on which the conclusions are based.

BAR-ADVANCE.

In treating this subject heretofore, the crest of bar has been taken for measurement of advance of the bars proper, and from observations, carried through a comparatively short period, of material carried in suspension by the river to the Gulf, estimates have been made of deposit in the Gulf—of that deposit which forms the foundation of the bars proper.

As the bar crests may have their location variously assumed by different persons, and knowing that 20 feet was the greatest depth of channel claimed over any one bar during the time covered by actual survey, my measurements of bar advance are based on advance of the outer 20-foot contours.

From these measurements for Pass à l'Outre, Southwest Pass, and South Pass, it appears that since 1860 the mean annual rate of advance has decreased. This may be due to the opening of Cubitt's Gap, through which a large volume of water has been discharging during the greater portion of the time stated. Like all crevasses, this one presents a deep basin between the river and the subdelta, which it is rapidly forming.

During the low stage of the river this basin has not been found less than 112 feet in depth, nor during the flood stage less than 127 feet, while the depth of the river opposite is but 54 feet.

The contours of the river opposite the crevasse, as well as the rapidity with which the crevasse subdelta is being built up, suggest that a large amount of the material moved along the river-bottom to this point is drawn into the crevasse by the vertical eddy thrown out toward the Gulf, and there carried by the swift current to aid in building up the shoals beyond. In no other way can the rapid growth of the "Cubitt" subdelta or of the "Jump" subdelta be accounted for.

This abstraction, above the Head of the Passes, of material that would otherwise have gone to the bars of the main passes, I have no doubt truly explains the noted decrease in mean annual rate of advance of bar proper.

Gulfward of the bars proper, which I assume to extend out to depths of 120 feet, begins the bar foundation made up by deposit of material

carried in suspension by the river waters, and in order of its specific gravity, gradually deposited by its carrier.

The distance from the bars proper, at which deposit begins, is as variable as the stage of the river, and as the winds which disturb the waters of the Gulf and change the direction of discharge of the river outlets.

The dividing line between bar proper and bar foundation has been assumed at 120 feet depths in the Gulf, because at about this depth marked evidence of mud-lump action ceases and marked deposit begins.

The surveys covering this bar foundation off the three main passes, out as far as depths of 300 and 350 feet, show conclusively that the growth of this foundation has been greatly underestimated in the past.

Profiles are submitted herewith, marked "A," which warrant the belief that if bar foundation several miles gulfward of the bars proper of Southwest Pass continues at the rate shown for the time covered by these surveys, it will, within a few years, come to the surface. The same may be said of Pass à l'Outre and South Pass, as the following memorandum of measurements will show:

MEMORANDUM.

The fill at Southwest Pass, 7½ miles out from the bar, between the surveys of March, 1874, and September, 1876, including three high-river periods, would take it to the surface in fifteen times as long, or forty-five years. At 60,000 feet out the fill was one-tenth the depth, giving thirty years to reach the surface at that place at the same rate.

Since Captain Talcott's survey, in 1838, the fill, at 57,000 feet out, has been 620 feet, which at the same rate continued would carry it to the surface in eighteen years.

The surveys at South Pass, in 1874 and 1875, include two high-river periods, and off the bar the fill is one-eleventh the depth of water at 25,000 feet from the crest, at which rate it would take twenty-two years to reach the surface; on a line farther east it would take twenty-eight years, and on the west line of soundings it would take twenty-six years.

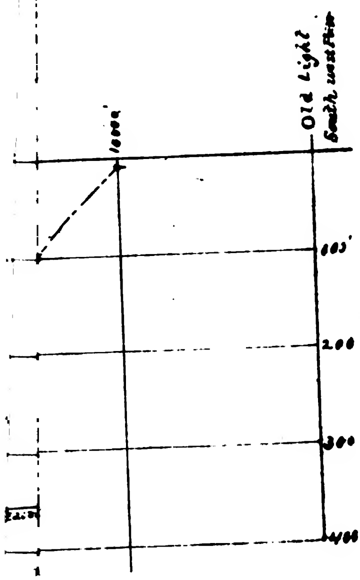
At Pass à l'Outre profiles give a period of but one year, and the fill at 7½ miles out was one-thirtieth of the depth.

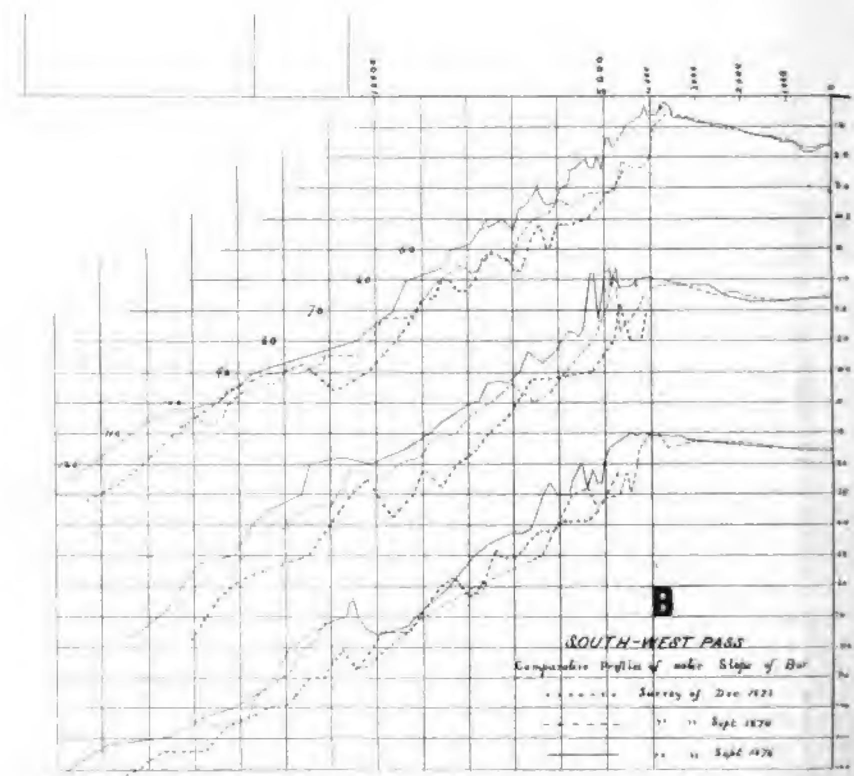
This may well be considered a startling development, because it suggests prolongation of the main stem of the river within a comparatively brief period, and with such prolongation the definite abandonment of all human effort to secure or maintain a "great open river-mouth," suited to the wants of commerce.

With the map of Louisiana before me I venture to trace four great eras marked by main-stem prolongation, taking the topographical features east of the main stem of the river and below the mouth of Red River as my guide.

The first subdelta terminated with the inclosure of Lake Maurepas. The first main-stem prolongation terminated in the formation of subdelta which inclosed Lake Pontchartrain, the second with that which shut in Lake Borgne, the third with that which formed the subdelta on which Forts Jackson and Saint Philip are built, and the fourth in the present subdelta.

It is noted that the last two subdeltas are smaller than those which preceded them, and the reason for this is quite apparent. On account of their protrusion they have been more exposed to the battering of the waves, and the advance of shore-line has thus been retarded, while the building of the bar foundation has been accelerated.


Old Light
200
300
400


SOUTH-WEST PASS

Attention is called to this, that it may be remarked that the subdelta now supposed to have nearly completed its cycle of formation is quite as large as the one just preceding it. It is further noted that each prolongation of main stem has been made in a general southeasterly direction, or, so to speak, in the face of the prevailing winds. This fact furnishes reason to think that future prolongation will be made through the Northeast Pass rather than through the narrow South Pass, or through "Cubitt's Gap."

Further reason is offered by the observed fact that the more easterly passes are comparatively short-lived.

Of the many such that have existed, and that can yet be traced, all but two—"Cubitt's Gap" and "North Pass"—are extinct, while the latter has been closing rapidly within the past ten years.

Since 1838 the Southeastern Pass, at its head, has gradually shoaled, and now presents but a depth of 27 feet at low-tide, low river, where it then presented 48 feet.

The South Pass at its head also shoaled, but in a less degree, up to the present year, when by artificial works it was deepened on the Southwest Pass side, while during the same period the Northeast Pass but slightly shoaled the bar at its head.

As profiles A are presented simply as a fair type of the many bar-foundation sections that have been made, so are profiles B herewith simply as a type of bar proper sections, and to illustrate some remarks on the part taken by the mud-lump formation in the work of bar-building.

It was long ago observed that the rise of mud-lumps above the surface of the water was, with rare exceptions, confined to the immediate vicinity of the outer-bar crests, and that as the bars advanced into the Gulf, leaving behind the lumps on the sides of the horseshoe-shaped crests, these latter lumps were gradually beaten down by the waves and lost in the extension of the marshy shores of the passes, while those in front disappeared after a comparatively brief existence.

Our surveys serve to explain this phenomenon, and lead to interesting conclusions as to the cause of mud-lump formation, and as to the important part it plays in the advance of bar proper. The outer slopes of the bars of the three main passes surveyed are found to consist of series of hilly ridges, which are nearly parallel to each other and to the outer crests of their bars.

These hillocks and ridges are incipient mud-lumps with their connections, and seem to be due to the gradual upheaval of the whole mud-lump stratum.

They advance gulfward as the bars advance, but at a lesser rate, so that they are gradually absorbed and lost in the body of the bars or in the advancing shore formation. As they move forward they gradually rise, and the peaks become sharper and sharper until they reach the surface near the bar-crest.

Those in front of the pass, as before remarked, are then lost and do not re-appear, even after the deep water inside the pass has advanced to the place of their first appearance above water. Those on the sides, on the contrary, remain above water, are subject to steady enlargement by the action of weather and waves, combined with continued gradual upheaval and occasional violent disturbance, like that which in April, 1875, in a few hours necessitated the abandonment of Pass à l'Outre and caused the partial closure of North Pass. From these and other observed facts I have come to the conclusion that the rise of mud-lumps is entirely due to pressure, and this I will explain, using Diagram C to illustrate. The diagram represents a section along the axis of a pass. On the diagram,

A B is taken to represent the original Gulf bottom. C′, C, C, &c., that stratum of material, carried by the river-water, the farthest from the bar-crests, and in part made up of the vegetable matter from which comes the "marsh gas" emitted from ruptured mud lumps. D D′ D′ represents the plastic blue-clay stratum overlying this. E and F represent the heavier deposits inside and outside the crests of the bars and resting upon this clay stratum. G represents the mass of deposit which during the lower stages of the river makes in the bed of the river and its passes, and which, after mid-stage, is rapidly moved down upon the bars. Immediately after this mass G begins to accumulate upon the inner slopes of the bars, the rise of lumps outside the bar-crests becomes very marked, as does also the advance of the crests. It appears probable that during the lower stages of the river, the deposit E is nearly balanced by F; hence, as observed, there is during that period but little change in position or shape of lumps, and that little such as can be traced to wave and weather action; but when G is added to E the equilibrium is at once disturbed. The added weight presses D down upon the soft mass C′, C C, and through this the pressure is transmitted to D′ D′ and there resisted by the weight of F—a weight which increases with distance from the bar-crests, and is comparatively stationary, while G is a moving mass of supposed nearly uniform thickness. The relations between E and F explain why it is that mud-lump ridges and peaks become flatter and less in height as they are more and more distant from their bar-crests. The pressure transmitted through C′, C C, &c., causes the most apparent and rapid changes along the line of least resistance, which is evidently a line just outside the bar-crests.

The part this formation plays in the formation of bar proper is an important one. I have called the formation the *nucleus* of bar formation. It presents a stubborn though slowly retreating barrier to the formation, by the river-current or by artificial means, of a deep channel through the bars it guards. Its corrugations catch and retain in place the heaviest deposits brought by the river to its bars, and its gradual upheaval and gulfward advance is apparently beyond control. Channels have been dredged through it, but experience has shown that to maintain them the labor must be as unintermitting as the action of the natural forces contended against. It is apparently the conservative element of bar-proper formation, since, wherever found active, the bar is distinguished by the steep outer slope; by a nearly uniform annual advance and a nearly equal normal depth of channel for all stages of the river. Such bars are never subject to rapid alteration in shape or depth of channel from the violent action of storms, and when artificially disturbed, within a wonderfully short period all evidence of such disturbance is obliterated.

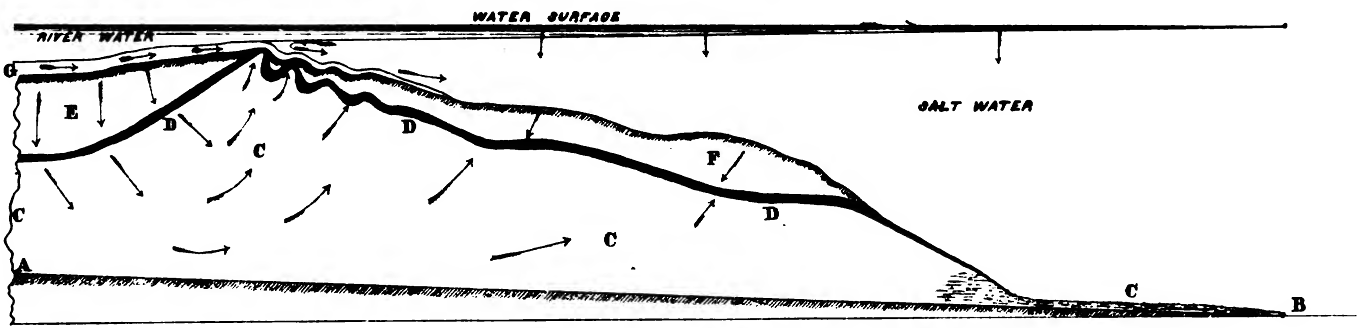
It is different with the bars of decayed passes and with those far advanced in decadence. With these the mud-lump formation has disappeared, though lying dormant beneath them.

The causes which, in the prime of these passes, brought it to the surface have long been in equilibrium. The bar proper, with its steep Gulf slope, has in consequence been lost in the gradual building up of bar formation and replaced by the long, gentle slope that characterizes this. The Atchafalaya, the Lafourche, and the Jump, which are yet very considerable passes, present examples.

The Southwest Pass is evidently in the earlier stages of decadence, judging from the shoaling at its head, the decreasing rate of advance of its bar, and the rapid building up in the Gulf in front of it.

The South Pass had far advanced toward decay; its mud-lumps had

DIAGRAM "C"



become dormant but had not all disappeared; it remains to be seen if the new conditions imposed upon the pass do not bring them to life and renewed activity.

The old Balize branch of the Northeast Pass appears far advanced in decay, having but about 5 feet of water across its bar, and as it has been narrowing rapidly at its head. The Pass à l'Outre branch, on the contrary, for the past few years has presented an example of remarkable mud-lump activity, and has, more nearly than any other pass, maintained its mean annual rate of advance of bar proper.

Subjects of investigation, other than those suggested by the above, have sufficient data collected for their consideration, but this has not yet been sufficiently studied. It seems, however, that they will bear out the following conclusions:

1. That when the river is in flood, and the Carrollton gauge-reading about 9 feet or over, there is a broad, thick sheet of deposit, which makes in the bed of the river and passes during the lower stages, that is sloughed along the bottom and so carried over the bar-crests and dumped on the outer slope of the bars proper.

2. That this movement ceases at or very near the point where the river-water commences rising upon the salt-water of the Gulf or at the so called "Dead Angle," the existence and location of which have been clearly established by numerous observations made at various stages of the river. The attending phenomenon, a refluent current, has been observed, and where of considerable velocity it has been measured, as also the velocity of the river-current. It has been observed that even at a high stage of the river the moving mass on the bottom has been checked in its movement by a rising tide.

3. Observation for amounts of material carried in suspension by the river-water, at various points in the river and its passes, on the crests and inner and outer slopes of the bars, and at various stages of the river, does not disclose any relation between velocity of current depth and width of cross-section and the amount carried. The assumption that this amount is directly proportioned to the velocity of current modified by depth is evidently an error. As nothing but assertion has yet been presented in its support it is perhaps not worth noticing.

4. Observations for a littoral current show conclusively that what has been mistaken for such are currents mainly if not wholly due to the winds. Their direction changes with the wind, as also does the direction of the river's discharge, thus causing a nearly uniform deposit over the whole face of the delta.

The assumption that these variable currents in being transmitted through and underneath the river-discharge cause scour of bottom has lately been added to the other assumption of a littoral current, with its elsewhere-observed effects. Measurement over an area of 51 acres directly in front of the works at South Pass has been cited in evidence of this scour.

The fact that the works at South Pass raise the surface of the water at their head indicates another, namely, that when the water is allowed to spread at their outer ends, some of the phenomena attending crevasses should be observed, and the most important of these is the vertical eddy by which a series of deep basins is made in and beyond the throat of the crevasse, with shoals beyond them.

The work is located in the collection-district of New Orleans, and near the light-house at Southwest Pass. It is not susceptible of permanent completion.

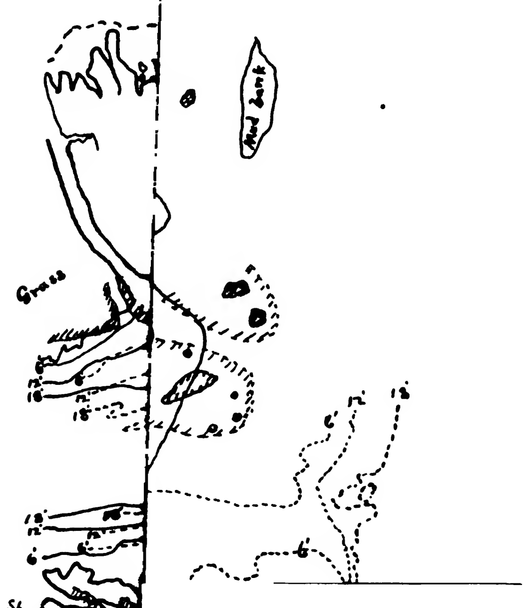
Whole amount appropriated	$1,327,224 38
Whole amount expended	1,310,539 63

Money statement.

July 1, 1876, amount available		$22,894 04
Amount appropriated by act approved August 14, 1876		100,000 00
		122,894 04
July 1, 1877, amount expended during fiscal year	$106,209 49	
July 1, 1877, outstanding liabilities	5,923 77	
		112,133 26
July 1, 1877, amount available		10,760 78
Amount that can be profitably expended in fiscal year ending June 30, 1879.		$150,000 00

ABSTRACT OF DISBURSEMENTS FOR IMPROVING MOUTH OF MISSISSIPPI RIVER FOR THE FISCAL YEAR ENDING JUNE 30, 1877.

Board	$131 86
Barge	1,769 90
Crescent City	666 34
End-dock scow	1,521 62
Essayons, machinery	5,858 42
Essayons, deck	3,440 27
Launch	755 34
Material	5,007 48
McAlester, machinery	11,052 99
McAlester, deck	1,862 10
Medicines	51 15
Provisions	9,161 25
Rent	1,311 00
Service	44,753 16
Stationery	399 56
Telegrams	444 37
Transportation	3,578 93
Coal	14,443 75
Total	106,209 49



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Tabular statement accompanying report of Capt C. W. Howell, United States Engineers, on improving the mouth of the Mississippi River, for the fiscal year ending June 30, 1877.

Date.	Stage of river at New Orleans, 12 m., below high water of 1874. Gauge foot of Canal street.	Wind at Southwest Pass.				Hours worked by dredge-boat.	Depth of channel at mean low tide.	Height of high tide above mean low tide.	Total depth of channel at high tide.	Least width at mean low tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties at Southwest Pass.			Remarks.
		6 a. m.		12 m.									Number of vessels aground.	Greatest draught.	Time of delay.	
		Direction.	Force.	Direction.	Force.											
1876.	Feet.					h. m.	Feet.	Feet.	Feet.	Feet.				Ft. in.	h. m.	
July 1	5.2	S. E.	2	S. E.	4	6 0						2		18 0		
2	5.0	S. E.	6	S. E.	3						3	4		18 0		Slack current.
3	5.0	S.	1	S.	2	8 0										
4	5.1	S. E.	5	S. E.	6	6 0					4	1		7 6		
5	5.1	S. E.	4	S. E.	4	6 0	16	2½	18½	80	2	3		17 0		
6	5.0	S. E.	5	S. E.	2	6 0					1	5	1	17 6	2 05	Steamer New Orleans, 17′ 6″, grounded on east side of channel, bound out.
7	4.9	E.	7	E.	7							1		15 3		
8	5.1	S. E.	1	S. E.	1	7 0	16	2½	18½	80		2		18 0		
9	5.1	S.	1	S.	1						2	3		17 6		
10	5.2	S. W.	3	W.	2	7 0					2	2		18 0		
11	5.3	S. E.	1	S. E.	1	7 0					2	4		16 0		
12	5.5	S. E.	1	S. E.	1		16	2½	18½	80	1	3	1	16 0	15	Steamer Ariel, 16′, bound in, grounded on west side of channel.
13	5.5	S.	2	S.	1							1		17 0		
14	5.4	S. W.	2	S. W.	1	11 0					1	4		16 6		
15	5.3	S. W.	1	W.	4		16½	2	18½	80	1			12 0		
16	5.4	S.	1	S.	2						1	1		15 0		
17	5.6	S. E.	3	S. E.	3	8 0					3	1		13 0		
18	5.8	W. N. W.	2	W. N. W.	3							2		6 0		
19	5.7	N. N. E.	3	E.	3		16½	3	19½	80		2		18 3		
20	5.7	E.	3	E. N. E.	4						1	4		16 6		
21	5.7	E.	1	E. N. E.	3	7 0					1			16 0		
22	5.8	E.	1	E.	2	6 0	16½	2½	19	80	1	1		18 3		
23	5.8	S. E.	3	S. W.	3						1	2		18 6		
24	5.6	S. W.	3	S. W.	3	6 0										
25	5.8	S. S. W.	2	S. E.	2						2			16 0		
26	5.8	S. S. E.	2	S. W.	3		16½	2	18½	80		1		15 0		
27	5.8	S. W.	3	S. S. E.	3	3 0						3		16 6		
28	5.8	S. W.	2	S. S. E.	3	9 0										
29	5.8	S. W.	2	S. W.	3		16½	2½	18½	80	2	2		15 0		
30	5.7	S. W.	3	S. W.	5							5		18 0		

Tabular statement accompanying report of Capt. C. W. Howell, United States Engineers, on improving the mouth of the Mississippi River, &c.—Continued.

Date.	Stage of river at New Orleans, 12 m., below high water of 1874. Gauge foot of Canal street.	Wind at Southwest Pass. 6 a. m. Direction.	6 a. m. Force.	12 m. Direction.	12 m. Force.	Hours worked by dredge-boat.	Depth of channel at mean low tide.	Height of high tide above mean low tide.	Total depth of channel at high tide.	Least width at mean low tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties at Southwest Pass. Number of vessels aground.	Greatest draught.	Time of delay.	Remarks.
1876.	*Feet.*					*h. m.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*				*Ft. in.*	*h. m.*	
July 31	5.7	W. N. W.	2	S. W.	5	6 0					2			15 0		
Aug. 1	5.8	N. W.	2	N. W.	2						4			15 0		
2	5.7	S. W.	3	S. W.	3		16½	2¼	19½	90	1	1		17 0		
3	5.8	E.	4	N. E.	7						2	1		17 0		
4	5.8	E.	6	S. E.	9											
5	5.7	S. S. W.	8	S. W.	4		16½	2½	19	80	2	1		16 0		
6	5.6	S. E.	3	S. E.	2	4 0					2	1		14 0		
7	5.6	E.	2	N. E.	3											
8	5.6	N. E.	4	E.	5						2	2		18 10		
9	5.9	E.	4	N. E.	6		16½	2½	19	80		2		17 0		
10	6.1	E.	5	E.	5						1	1		15 0		
11	6.1	E. N. E.	5	E. N. E.	5						1	1		18 0		
12	6.4	E.	4	E.	4		16½	2¼	19	80	2	1		15 0		
13	6.8	E.	3	E.	2	7 0					2	3		15 0		
14	7.7	E.	2	E.	2							1		15 0		
15	7.5	S. W.	2	S. W.	2						1	1		15 0		
16	7.7	S. W.	1	S. W.	1		16½	3	19½	100		1		18 0		
17	8.0	S. W.	2	S. W.	4						1	4	1	18 10	97 30	Ship Scotia, 18′ 10″, bound out, grounded east of channel, at 7 a. m. Went to sea 8.30 a. m., August 21.
18	8.3	S. W.	4	W. S. W.	4						1			13 0		
19	8.5	W.	3	W.	3		16½	2¼	19	100	2	1		16 6		
20	8.7	N. N. W.	3	S. W.	3						1	1		16 0		
21	8.9	W.	3	S. W.	6						2	1		18 10		
22	9.0	W.	4	W.	2		16½	2¼	18¾	100	1	1		15 0		
23	9.0	S. S. E.	3	S. S. E.	2							4		19 3		
24	9.0	S.	1	E.	2						3	2		15 0		
25	9.4	E. N. E.	1	E. N. E.	4						1					
26	9.4	E. N. E.	2	E. N. E.	4	1 0	16½	2¼	18¾	80	3					
27	9.5	E.	2	S. E.	2							4		18 0		
28	9.6	S. W.	2	W. N. W.	3						2	1				Essayons taking deep-sea soundings.
29	9.1	W.	2	S. W.	2											Do.
30	9.9	E.	2	E.	3						2	1				Do.
31	9.8	E.	3	S. W.	3							1		15 0		Do.

Sept.	1	10.0	S. W.	3	S. W.	1						3			16	0		Do.
	2	10.1	S. E.	1	S. W.	2		16½	2¼	18¾	80	1	1		16	0		Do.
	3	10.2	S. W.	1	W.	2						3			15	0		
	4	10.4	N. W.	2	N. W.	1							1		15	0		
	5	10.5	W.	1	S. W.	2												Essayons taking deep-sea soundings off South Pass.
	6	10.6	S. E.	2	W.	2												Do.
	7	10.6	S. E.	4	S. E.	3						2	3		16	0		Do.
	8	10.7	E.	2	E.	3						2	1		19	0		Do.
	9	10.8	E.	1	E.	2		16½	2¼	18¾	80	3			16	6		
	10	11.0	S. W.	1	S. W.	1						1	1		15	6		
	11	11.1	W.	3	S. W.	3							1		12	0		
	12	11.4	W.N.W.	2	W.N.W.	2							1		8	0		
	13	11.3	W.N.W.	2	W.N.W.	2		17	2½	19¼	100	1	2		18	0		
	14	11.5	W.N.W.	1	W.N.W.	2						2	3		18	0		
	15	11.6	W.N.W.	3	W.N.W.	3						1			15	0		
	16	11.5	N.	3	N.	3		17	2¼	19½	100	1			17	0		
	17	11.5	N.	2	N.	2						5	1		17	6		
	18	11.7	N. W.	2	N. W.	1												
	19	11.6	S. E.	4	S.E.	4						1	1		13	0		
	20	11.5	S. W.	5	W.	6		16½	2	18¾	100	4	2		18	6		
	21	11.2	S. W.	5	S. W.	7						2	1	1	16	0	*48 0	†Steamer Hudson, 16′, bound out, grounded east of channel. Got off September 23.
	22	11.0	S. W.	2	S. W.	3								1	14	0	*12 0	†Steamer Federico, 14′, bound in, grounded east of channel. Got in September 23.
	23	11.0	S. W.	2	S. W.	2		16½	2¼	18¾	100	2	2	2	16	6	44 0	†Steamer New Orleans, 16′, and bark Martha Cobb, 16′ 6″, bound in, grounded east of channel. Got off September 24.
	24	10.7	N. W.	2	N. W.	1						3	4	2	18	8	*101 0	†Steamer Abdiel, 18′ 6″, bound out, grounded east of channel. Got off September 28. Bark Reine des Anges, 15′ 6″, was delayed five hours.
	25	10.6	W.	1	W.	2						1	1		15	0		
	26	10.4	N. W.	2	N. W.	1	7 0					1	2		18	6		
	27	10.0	N.	4	N.	7		16	2¼	18¼	100	1			15	0		
	28	9.8	N.	2	N.	1						4	3		18	0		
	29	9.6	N.	2	N.	2						3			18	6		
	30	9.6	N.	6	N.	4		16	2¼	18¼	100	3			17	4		
Oct.	1	9.8	N.	5	N. W.	5						1	5		15	0		
	2	10.0	N.	5	N.	4						5			18	0		
	3	10.1	N.	3	N. E.	2						2	1		19	1		
	4	10.3	N.	2	N.	2		16½	2	18¾	100	1	2	1	19	6	1 0	Bark Reynaud, 19′ 6″, bound out, was one hour crossing bar.
	5	10.2	E.	1	E.	4						6	4	1	18	0	8 0	Ship D. W. Chapman, 18′, bound in, grounded east of channel.
	6	10.1	N.	2	N.	2						7	2	1	15	0	4 0	Ship Saranak, 15′, bound in, grounded east of channel.
	7	9.9	N.	5	N.	5		16½	2¼	18¼	100	2			15	0		
	8	9.5	N.	5	N.	5												
	9	9.3	N.	6	N.	5						2			15	0		
	10	9.4	N.	3	N.	2						2			17	0		
	11	9.6	N.	3	N.	2		16½	2⅜	19	100	1	2		14	0		
	12	9.8	N.	2	N.	2						2	2		19	6		

*About. †These detentions were caused by a very strong easterly current and strong west winds, which drove the vessels to the eastward of the channel.

Tabular statement accompanying report of Capt. C. W. Howell, United States Engineers, on improving the mouth of the Mississippi River, &c.—Continued.

Date.	Stage of river at New Orleans, 12 m., below high water of 1874. Gauge foot of Canal street.	Wind at Southwest Pass. 6 a. m. Direction.	6 a. m. Force.	12 m. Direction.	12 m. Force.	Hours worked by dredge-boat.	Depth of channel at mean low tide.	Height of high tide above mean low tide.	Total depth of channel at high tide.	Least width at mean low tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties at Southwest Pass. Number of vessels aground.	Greatest draught.	Time of delay.	Remarks.
1876.	*Feet.*					*h. m.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*				*Ft. in.*	*h. m.*	
Oct. 13	10.1	N.	2	N.	3	......	......	......	......	......	7	3	......	17 0	......	
14	10.7	N.	2	N.	2	......	......	......	......	......	1	......	......	15 0	......	
15	11.2	N.	3	N.	5	......	......	......	......	......	3	3	2	17 6	177 0	Steamer New Orleans, 17′, grounded east of channel. Got off October 16. Ship Waterloo, 17′ 6″, grounded west of channel. Got off October 21.
16	11.5	N.	3	N.	3	......	......	......	......	......	5	1	......	18 6	......	
17	11.3	N.	2	N. N. E.	2	......	......	......	......	......	2	4	1	19 8	13 0	Steamer Borussia, 19′ 8″, grounded east of channel. Got off October 18.
18	11.6	N.	2	N.	2	......	16½	2½	19	90	4	1	......	19 8	......	
19	......	N. N. E.	2	N.	2	......	......	......	......	......	2	4	......	18 6	......	
20	Repairing gauge.	N. E.	1	N. E.	1	......	......	......	......	......	3	3	......	18 0	......	
21		S. E.	2	S. E.	1	......	16½	2¾	19¼	90	2	3	......	18 0	......	
22		S. E.	4	E. S. E.	4	......	......	......	......	......	3	2	......	16 0	......	
23		W.	5	N. W.	5	......	......	......	......	......	......	3	......	17 6	......	
24		N. W.	2	S. W.	1	......	......	......	......	......	......	2	......	17 6	......	
25		W.	2	W.	2	......	16½	2	18½	100	......	2	......	17 3	......	
26		N. E.	1	N. E.	1	......	......	......	......	......	1	4	......	19 6	......	
27		N. E.	1	N. E.	2	......	......	......	......	......	3	2	......	17 0	......	
28		E. N. E.	2	E.	2	......	16½	1½	18	90	4	......	......	17 3	......	
29		E.	2	E.	2	......	......	......	......	......	4	4	......	18 3	......	
30		E.	2	E.	2	......	......	......	......	......	5	......	......	17 0	......	
31		E.	2	N. E.	2	......	......	......	......	......	7	3	1	17 6	18 0	Steamer Minerva, 17′ 6″, grounded west of channel. Got off November 1.
Nov. 1		E.	3	E.	3	......	16½	2½	19	100	1	2	......	18 0	......	
2		N. W.	4	N. W.	2	......	......	......	......	......	1	2	......	16 0	......	
3		N.	3	N.	3	......	......	......	......	......	2	5	1	16 6	1 0	Steamer New Orleans, 16′ 6″, grounded east of channel.
4		N. E.	3	N.	3	......	16½	3	19½	100	2	4	......	18 0	......	
5		N.	2	N. W.	3	......	......	......	......	......	4	5	......	17 0	......	
6		S.	1	S.	2	......	......	......	......	......	2	......	......	16 0	......	
7		N.	5	N.	6	......	......	......	......	......	1	1	......	15 0	......	
8		N.	3	W.	3	......	16½	2½	19	100	1	5	......	17 0	......	
9		N.	2	N.	2	......	......	......	......	......	3	6	......	18 0	......	

	10		N.	2	N.	2	......	......	......	......	......	3	3	....	18 0	....	
	11		N.	1	N. E.	2	......	16½	1½	18	100	2	2	....	18 0	....	
	12		E.	2	E.	3	......	......	......	......	......	2	5	....	19 3	....	
	13		N. E.	4	E.	2	......	......	......	......	......	5	1	....	17 0	....	
	14		E.	1	E.	1	......	......	......	......	......	9	2	....	16 6	....	
	15		N.	2	N.	3	......	16½	2½	19	100	......	6	....	18 6	....	
	16		N.	2	N. E.	2	......	......	......	......	......	6	5	....	19 6	....	
	17		N. E.	1	E.	1	......	......	......	......	......	9	3	....	18 0	....	
	18		S. W.	1	N. W.	2	......	16½	2½	19	100	2	2	....	15 0	....	
	19		N. W.	4	N. W.	4	......	......	......	......	......	1	3	....	18 2	....	
	20	13.7	N.	1	N.	1	......	......	......	......	......	1	1	....	14 0	....	
	21	13.6	N. E.	1	N. E.	1	......	......	......	......	......	......	......	....	......	....	
	22	13.7	N. W.	1	N. W.	1	......	16½	2	18½	90	3	4	....	18 0	....	
	23	13.4	N.	2	N.	6	......	......	......	......	......	5	5	1	19 8	3 30	Steamer Hudson, 19′ 8″, bound out, grounded on east side of channel.
	24	13.2	N.	5	N.	3	......	......	......	......	......	3	3	1	18 3	7 15	Steamer Hanover, 18′ 3″, bound out, grounded on west side of channel.
	25	13.1	N. W.	5	N. W.	3	......	16	2	18	90	8	3	....	16 9	....	
	26	13.3	N.	3	N. E.	2	......	......	......	......	......	6	4	....	17 6	....	
	27	13.5	N. W.	5	S. W.	2	......	......	......	......	......	5	2	....	15 0	....	
	28	13.8	S. W.	2	S.	2	......	......	......	......	......	7	2	....	16 6	....	
	29	13.9	S. W.	2	S. W.	2	......	16	2½	18½	90	3	3	....	17 6	....	
	30	13.8	N. N. W.	5	N. N. W.	5	3 0	......	......	......	......	......	4	1	18 0	*5 0	Bark Almira Robinson, 18′, bound out, grounded east of channel.
Dec.	1	14.4	N. N. W.	7	N. N. W.	7	......	......	......	......	......	2	7	2	18 0	5 0	Ship Atmosphere, 18′, and bark America, 17′, were, the former 3 hours and the latter 2 hours crossing bar.
	2	14.7	N. N. W.	4	N. N. W.	3	......	16	2½	18½	90	2	4	....	16 6	....	
	3	14.7	N. N. W.	3	N. N. W.	4	......	......	......	......	......	1	2	1	19 0	*48 0	Ship Baden, 19′, bound out, grounded east of channel.
	4	14.9	N. N. W.	4	N. N. W.	4	7 0	......	......	......	......	7	4	....	16 6	....	
	5	14.6	N. N. W.	5	N. N. W.	5	9 0	......	......	......	......	4	3	....	19 0	....	
	6	14.4	N. N. W.	3	N. N. W.	3	......	......	......	......	......	1	3	1	16 6	2 0	Ship Martha Cobb, 16′ 6″, was 2 hours crossing bar.
	7	14.8	N.	2	N.	2	......	16	2½	18½	90	4	8	....	19 0	....	
	8	14.4	N.	2	N. W.	5	......	......	......	......	......	2	3	1	19 0	167 0	Steamer Belgravia, 19′, bound out, grounded east of channel. Got off December 15.
	9	14.3	N. W.	5	N.	5	......	16	2	18	100	3	1	1	19 9	19 0	Steamer Diego, 19″ 9′, bound out, grounded west of channel. Got off December 10.
	10	13.9	S.	4	S.	2	......	......	......	......	......	11	2	....	19 9	....	
	11	13.6	W.	2	W.	1	......	......	......	......	......	5	4	....	15 0	....	
	12	13.6	N. W.	2	N.	1	......	......	......	......	......	3	......	1	19 0	27 0	Steamer Emiliano, 19′, bound out, grounded west side of channel. Got off December 13.
	13	13.8	S. W.	1	E.	2	......	16	2	18	100	3	1	....	19 0	....	
	14	14.1	E.	1	E.	2	......	......	......	......	......	4	5	....	19 6	....	
	15	14.2	N.	6	N.	6	......	......	......	......	......	7	7	....	19 0	....	
	16	14.0	N.	5	N.	5	......	......	......	......	......	12	5	....	18 0	....	
	17	14.2	E.	2	E.	3	......	16	2½	18½	100	8	4	....	18 0	....	
	18	14.6	W.	2	N.	5	......	......	......	......	......	3	9	1	19 0	213	Ship Morning Star, 19 feet, bound out, grounded east of channel. Got off December 27.
	19	14.7	N. N. W.	4	N. N. W.	3	......	......	......	......	......	7	2	....	17 0	....	

*About.

Tabular statement accompanying report of Capt. C. W. Howell, United States Engineers, on improving the mouth of the Mississippi River, &c.—Continued.

Date.	Stage of river at New Orleans, 12 m., below high water of 1874. Gauge foot of Canal street.	Wind at Southwest Pass. 6 a. m. Direction.	6 a. m. Force.	12 m. Direction.	12 m. Force.	Hours worked by dredge-boat.	Depth of channel at mean low tide.	Height of high tide above mean low tide.	Total depth of channel at high tide.	Least width at mean low tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties at Southwest Pass. Number of vessels aground.	Greatest draught.	Time of delay.	Remarks.
	Feet.					*h. m.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*				*Ft. in.*	*h. m.*	
1876. Dec. 20	14.9	N.	2	E.	2		16½	2	18½	100	3	4		17 0		
21	14.7	S. E.	4	S.	4						3	2		19 6		
22	14.2	S. W.	4	W.	3						9	1		17 0		
23	14.6	N.	4	N.	5		16	1¾	17¾	100	4	3		18 0		
24	14.8	S.	2	S. W.	3						9	3		17 0		
25	14.8	N. W.	5	N.	5						4	7		18 6		
26	15.3	N.	6	N.	4						3	7		18 0		
27	15.3	N.	4	N.	4						1	6		19 0		
28	15.1	N.	5	N.	3		16½	2	18½	100		5		19 0		
29	15.3	W. N. W.	8	W. N. W.	8						1	1	1	16 6	96	Bark Granville Belle, 16′ 6″, bound out, grounded 300 feet east of channel. Got off January 2.
30	15.4	N.	6	N.	3		16	2¼	18¼	100	3	5		18 6		
31	15.5	N.	7	E.	10						3			13 0		
1877. Jan. 1		S. W.	6	N. W.	6						1	1		16 0		
2		N. W.	3	N. W.	2							8		19 0		
3		N. W.	1	N. W.	2		16	1¾	17¾	100	1	8		17 0		
4		N.	2	N.	2						2	1		19 0		
5		N.	2	N. E.	2						12	2		18 0		
6		W. S. W.	3	W.	5		16	2	18	100	3	3		18 0		
7		N. W.	3	E.	1						1	8	1	19 6	44	Steamer Borussia, 19′ 6″, bound out, grounded on west side of channel. Got off January 9.
8		S.	3	N. W.	6							1		8 0		
9		N.	5	N.	5						1	3	1	18 0	18	Ship Queen of Australia, 18′, bound out, grounded west side of channel. Got off January 10.
10	15.5	E.	3	N. E.	3						4	4		18 0		
11	15.5	N. E.	2	N. E.	2		16	2	18	100	2	2		18 6		
12	15.6	E.	2	E.	2						1			15 0		
13		E.	1	E.	1						5			16 0		
14		E.	1	S. E.	1						2	1		15 0		
15		E.	1	S. E.	1						5			19 0		
16	14.7	N.	2	N. E.	4						3	4		18 6		
17	15.2	E.	2	E.	2		16	2	18	100		11		18 0		

	18	15.1	E.	1	N. E.	2	......	......	......	......	......	......	1	....	18 0	....	
	19	15.2	E.	1	E.	3	......	......	......	......	......	4	13	....	18 0	....	
	20	15.2	S. W.	2	S. W.	2	......	16	2	18	100	1	7	....	17 6	....	
	21	14.9	S. E.	2	S. W.	2	......	......	......	......	......	3	12	....	19 0	....	
	22	....	N.	2	N. E.	2	......	......	......	......	......	3	3	....	17 0	....	
	23	14.5	N.	4	N.	4	......	......	......	......	......	1	2	....	18 0	....	
	24	14.5	N.	4	N.	4	......	16	2	18	100	4	18	....	18 6	....	
	25	14.1	N.	3	N.	3	......	......	......	......	......	......	5	....	18 6	....	
	26	13.2	N.	2	N.	2	......	......	......	......	......	4	7	1	17 6	5	Bark Tancred, 17′ 6″, bound out, grounded east side of channel.
	27	12.1	N.	2	N.	2	......	16	2	18	100	1	4	....	15 0	....	
	28	11.4	N.	2	N.	2	......	......	......	......	......	3	3	....	18 4	....	
	29	10.1	N.	2	N.	1	8 0	16	1¾	17¼	100	4	1	....	15 0	....	
	30	9.2	N.	2	N.	2	9 0	16	1¼	17¾	100	......	3	....	18 6	....	
	31	8.6	N.	2	N.	2	7 0	17	1½	18½	60	1	1	....	16 0	....	
Feb.	1	8.1	N.	3	N.	3	9 15	17	1½	18½	80	4	7	....	19 0	....	
	2	8.1	N. E.	2	N. E.	3	9 0	17¼	1½	19	60	2	2	....	16 0	....	
	3	7.6	E.	2	S. E.	4	8 0	17½	1¾	19¼	80	2	3	....	18 6	....	
	4	7.5	N. W.	2	N. W.	4	6 30	17½	2	19½	70	......	5	1	17 6	30 10	Ship Glad Tidings. 17′ 6″, bound out, grounded across channel. Got off February 5.
	5	7.2	N. W.	2	N. W.	4	7 40	17	2	19	100	1	1	....	17 6	....	
	6	7.1	N. W.	2	N. W.	4	7 45	17½	2	19½	60	4	5	1	18 0	17	Ship Malta, 18′, bound out, grounded west side of channel. Got off February 7.
	7	7.1	N. W.	3	N. W.	2	6 30	17	2¼	19¼	100	1	7	....	18 0	....	
	8	7.0	N. W.	2	W.	4	9 25	17	2¼	19¼	100	......	......	....	....	....	
	9	7.1	W.	4	S. W.	4	8 45	......	......	......	......	1	......	....	15 0	....	
	10	7.1	W.	4	W.	4	9 35	17	2¼	19¼	80	1	8	....	16 0	....	
	11	7.0	N. W.	3	N. W.	2	9 0	17	2	19	100	3	4	....	16 0	....	
	12	7.0	N.	2	N.	4	8 30	17	2	19	100	......	3	....	13 0	....	
	13	7.0	N.	4	N. E.	4	8 35	17	2	19	100	1	5	....	16 6	....	
	14	7.7	W.	3	W.	4	6 30	17	2	19	120	2	......	....	15 0	....	
	15	7.8	W.	4	N.	4	10 0	17	1¾	18¾	120	5	1	....	15 0	....	
	16	7.7	N.	4	N.	5	11 0	......	......	......	......	3	6	....	16 6	....	
	17	8.4	N.	4	N.	4	4 35	17½	2	19¼	100	1	2	....	18 6	....	
	18	8.8	N.	1	N.	1	3 35	17½	1½	19¼	100	2	6	....	19 0	....	
	19	8.5	W.	2	W.	3	3 50	17½	1¾	19¼	100	2	......	....	14 0	....	
	20	8.8	N. W.	4	N. W.	6	2 25	17½	1¾	19¼	100	2	2	....	19 6	....	
	21	8.9	N. W.	3	N. W.	3	6 35	18	1¼	19¾	80	1	1	....	19 7	....	
	22	8.7	N.	2	N.	3	7 0	......	......	......	......	3	6	....	19 0	....	
	23	9.2	S. W.	3	S. W.	5	......	18	2	20	100	......	......	....	....	....	
	24	9.3	N.	2	N. W.	1	6 40	18	1¾	19½	90	3	3	....	18 0	....	
	25	9.2	N. E.	4	N. E.	3	8 45	18	2	20	100	......	6	2	19 0	23 55	Bark Renom, 18′, grounded west side of channel. Ship Tirrell, 19′, grounded west side of channel.
	26	9.1	N. E.	4	N. E.	4	10 0	18	1½	19½	100	5	2	....	19 0	....	
	27	9.0	N.	4	N.	4	10 40	18	1¾	19¾	80	4	3	....	19 0	....	
	28	9.2	N.	2	N.	3	10 35	......	......	......	......	3	3	1	19 0	3 0	Ship Advance, 19′, grounded west side of channel.
Mar.	1	9.1	E. N. E.	6	E. N. E.	7	......	......	......	......	......	2	......	....	12 0	....	
	2	9.4	S. W.	4	S. E.	2	10 40	18	2	20	100	2	3	....	18 6	....	
	3	10.0	S. E.	2	S.	2	7 0	18	1¾	19½	100	2	3	....	19 3	....	
	4	10.7	S.	1	S. E.	2	......	......	......	......	......	2	4	....	17 0	....	
	5	11.0	S. E.	2	N. W.	7	......	18½	1½	20¼	70	......	3	....	15 6	....	
	6	11.1	N. E.	5	N. E.	5	......	18½	1¼	20¼	100	1	1	1	17 6	5 45	Bark Energia, 17′ 6″, grounded west side of channel.

Tabular statement accompanying report of Capt. C. W. Howell, United States Engineers, on improving the mouth of the Mississippi River, &c.—Continued.

Date.	Stage of river at New Orleans, 12 m., below high water of 1874. Gauge foot of Canal street.	Wind at Southwest Pass. 6 a. m. Direction.	6 a. m. Force.	12 m. Direction.	12 m. Force.	Hours worked by dredge-boat.	Depth of channel at mean low tide.	Height of high tide above mean low tide.	Total depth of channel at high tide.	Least width at mean low tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties at Southwest Pass. Number of vessels aground.	Greatest draught.	Time of delay.	Remarks.
1877.	*Feet.*					*h. m.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*				*Ft In*	*h. m.*	
Mar. 7	11.3	N. E.	4	E.	4	......	18¾	1½	20¼	100	1	5	......	19 0	......	
8	11.5	S. E.	6	S. E.	8	......	......	......	......	......	1	1	......	19 0	......	
9	11.8	S. W.	5	N. W.	5	......	......	......	......	......	2	5	......	18 6	......	
10	12.3	N.	5	N.	5	4 45	18	1½	19½	100	3	1	......	16 0	......	
11	12.2	N. E.	3	N. E.	3	......	18	1½	19½	100	3	5	......	18 0	......	
12	12.2	N. E.	3	E.	4	......	18	1½	19½	100	1	1	......	16 0	......	
13	12.4	E.	3	E	3	......	18	1⅜	19⅜	100	3	4	......	19 0	......	
14	12.4	N. W.	2	N. W	2	......	18	1¼	19¼	100	4	......	......	15 0	......	
15	12.2	N.	2	E.	3	......	18	1⅜	19⅜	100	3	......	......	15 0	......	
16	12.0	S. E.	3	S. E.	3	......	18	1⅜	19⅜	100	3	2	......	19 0	......	
17	12.1	S.	2	W.	3	......	18	1¾	19¾	100	3	3	......	16 0	......	
18	12.0	N. W.	5	N.	3	......	18	1¾	19¾	100	......	9	......	16 6	......	
19	12.0	E.	3	E.	2	......	18	1½	19½	100	4	1	1	19 10	25 05	Steamer Memphis, 19′ 10″, grounded on outer mud lump; got off March 20.
20	11.9	E.	4	E.	4	......	18	2	20	100	......	1	......	12 0	......	
21	Gauge taken up.	W.	3	W.	2	......	18	2	20	100	......	3	......	18 6	......	
22		N. E.	1	N. E.	1	......	18	2	20	100	1	2	......	17 6	......	
23		E. S. E.	1	S. E.	1	......	18	2	20	100	......	6	......	19 0	......	
24		S. E.	2	S. E.	2	......	18	2	20	100	2	1	......	15 0	......	
25		S. W.	4	W.	4	......	18	1¾	19¾	100	......	2	......	17 0	......	
26		N. W.	5	N. W.	3	......	18	1¾	19¾	100	......	1	......	17 6	......	
27		S. W.	4	S. W.	4	......	18	1½	19½	100	......	1	1	17 6	5 0	Steamer Ithuriel, 17′ 6″, was detained 5 hours in crossing bar.
28		S. W.	1	S. E.	2	......	18	1⅜	19⅜	100	......	......	......	......	......	
29		S.	1	S.	1	6 0	18	1½	19½	100	......	2	......	16 6	......	
30		E.	2	E.	3	3 0	18	1⅝	19⅝	100	......	2	1	20 6	21 45	Steamer Borussia, 20′ 6″, grounded on outer mud-lump; got off March 31.
31		E.	3	E.	3	......	18	2	20	100	3	2	1	17 6	73 0	Ship John Patten, 17′ 6″, grounded west side of channel; got off April 3.
April 1		E.	4	E.	4	......	18	2	20	100	8	1	......	17 0	......	
2		E.	1	E.	1	5 30	18	1¾	19¾	100	3	1	1	15 6	1 45	Ship Geo. Peabody, 15′ 6″, grounded west of channel.
3	7.4	N. E.	2	E.	2	10 0	......	......	......	......	......	2	......	17 6	......	
4	7.2	E.	1	E.	2	6 0	18	2	20	100	1	4	......	17 0	......	

	5	7.1	E.	1	E.	1							4		16 0		
	6	6.9	S.E.	3	E.	3	6 0	18	2	20	100	7	5		18 0		
	7	6.7	E.	4	S.E.	6						6	1		19 6		
	8	6.5	S.W.	7	S.W.	8						2	1		15 0		
	9	6.7	N.N.W.	5	S.W.	5						3	2		15 0		
	10	6.4	E.	3	E.	2	13 0	17	1½	18½	60	2	4	1	18 6	22 0	Ship Warsaw, 18′ 6″, grounded on outer lump. Got off April 11.
	11	6.3	E.	3	E.	5	12 15	17½	1½	19	80	2	6	1	18 6	141 15	Ship Revolving Light, 18′ 6″, grounded west side of channel. Got to sea April 17.
	12	5.8	E.N.E.	7	E.N.E.	7						1			8 0		
	13	5.3	N.W.	7	N.W.	6	3 0										
	14	5.4	W.	2	W.	2	11 20	17	2	19	100	4	2		15 0		
	15	5.2	W.	1	W.	1	11 50	17	1½	18½	100						
	16	5.1	E.	2	S.E.	3	11 30	17	2½	19½	80	1			16 0		
	17	5.0	S.E.	2	S.E.	2	6 20	17½	2½	20	100	3	3		19 0		
	18	5.2	S.E.	7	S.E.	4	5 0						2		20 0		
	19	5.1	S.S.E.	4	S.W.	4	5 40	17½	2½	20	100	2	2		18 0		
	20	5.1	S.W.	2	S.W.	3	5 30	18	2½	20½	80	2	2		8 0		
	21	5.2	N.W.	4	E.	4	12 30	18	2	20	80		3		18 8		
	22	5.0	E.N.E.	2	E.	4	11 30	18	2	20	80	1	3	1	19 6	65 35	Steamer Hannover, 19′ 6″, grounded on west side of channel. Got off April 25.
	23	4.9	E.	3	E.	6		17	2	19	100	1			8 0		
	24	5.1	E.	4	E.	3	6 0	17	2	19	80	1			12 0		
	25	4.6	E.	2	E.	3	8 0	17	2	19	100		4		19 6		
	26	4.4	E.	3	E.	2	6 0	17½	2½	19¾	100	2	1		12 0		
	27	4.3	E.	5	E.	2	8 30					1	2		17 0		
	28	4.2	S.W.	3	W.	2	11 0	18	3	21	70	1	2		12 0		
	29	4.3	N.W.	4	N.W.	4	12 0	18	3	21	90		8		16 0		
	30	4.4	N.W.	4	N.W.	2	8 25	18	3	21	90	2			10 0		
May	1	4.2	N.E.	2	E.	2	7 35	18	2½	20½	90	2			12 0		
	2	4.3	N.W.	1	N.W.	1	6 0	18	2½	20½	100		6	1	17 6	20 0	Brig Onolaska, drawing less than 15 feet, grounded east of channel.
	3	4.2	E.	3	E.	3	11 0	18	2½	20½	90		2		17 0		
	4	4.2	N.E.	2	S.W.	4	4 25	18	2	20	90	1	4		20 0		
	5	4.3	W.	1	E.	2	6 15	18	2½	20½	80	1	1		19 0		
	6	4.3	E.	1	S.E.	2	6 30	18	2½	20½	90	1			15 0		
	7	4.2	N.W.	4	N.W.	2	7 45	18	2	20	90		2		18 0		
	8	4.4	N.W.	3	N.W.	3	9 0	18	1¾	19¾	90	2	4	1	18 0	3 0	Ship Genevieve Strickland, 18 feet, was three hours crossing bar.
	9	4.0	N.W.	2	N.E.	2	12 0	17	2	19	90	1	1		10 0		
	10	4.2	E.	1	E.	2	11 15	17	2	19	100	2	4		19 4		
	11	4.1	E.S.E.	3	E.S.E.	3	11 0	17½	2½	19¾	100		2		18 6		
	12	4.1	E.	2	E.N.E.	4	10 0	17½	2½	20	100	1	3		19 8		
	13	4.1	E.	5	E.	3	8 30	17½	2½	20	100	1			8 0		
	14	3.8	E.	5	E.	6	6 30	17½	3	20½	100	4	1		19 3		
	15	3.6	E.	3	E.	5		17½	3	20½	100	1	1		15 0		
	16	3.9	E.N.E.	3	E.N.E.	5						2	3		18 6		
	17	4.0	E.	2	E.N.E.	4	5 0	17½	2½	20½	100	3	1		19 6		
	18	4.1	E.N.E.	1	E.N.E.	3	5 25						4	1	19 11	27 40	Bark Montebello, 19′ 11″, grounded on west side of outer mud-lump.
	19	4.0	N.E.	3	E.	3	6 0	17½	2½	20½	100	1	1		19 11		

Tabular statement accompanying report of Capt. C. W. Howell, United States Engineers, on improving the mouth of the Mississippi River, &c.—Continued.

Date.	State of river at New Orleans, 12 m., below high water of 1874. Gauge foot of Canal street.	Wind at Southwest Pass. 6 a. m. Direction.	Force.	Wind at Southwest Pass. 12 m. Direction.	Force.	Hours worked by dredge-boat.	Depth of channel at mean low tide.	Height of high tide above mean low tide.	Total depth of channel at high tide.	Least width at mean low tide.	Number of vessels passed in.	Number of vessels passed out.	Casualties at Southwest Pass. Number of vessels aground.	Greatest draught.	Time of delay.	Remarks.
1877.	Feet.					h. m.	Feet.	Feet.	Feet.	Feet.				Ft. in.	h. m.	
May 20	4.1	E.	1	S. E.	1	11 0	17	2¼	19¼	100	1	2	1	19 8	139 0	Ship Arcturus, 19′ 8″, grounded west side of channel. Got off May 26.
21	3.8	S. W.	1	S. W.	1	11 0	17	2	19	100	......	5	....	15 0	....	
22	4.1	W.	3	W.	2	11 0	17	2	19	100	......	......	....	....	....	
23	4.0	N. W.	2	S.	2	......	17	2¼	19¼	100	1	1	....	12 0	....	
24	3.9	N. E.	1	N. E.	2	11 0	16⅝	2⅜	19	100	......	1	....	15 0	....	
25	3.8	N. E.	1	N. E.	1	......	16⅝	2⅝	19¼	70	3	......	....	8 0	....	
26	3.9	N. E.	1	N. E.	1	10 40	16½	2¾	19¼	90	......	2	1	20 5	22 0	Ship Bombay, 20′ 5″, took the bar contrary to orders and grounded above Cleopatra buoy.
27	4.0	N. E.	1	N. E.	2	......	16½	2¾	19¼	90	1	2	1	19 10	21 45	Ship Northampton, 19′ 10″, grounded near lower Black Spar.
28	3.9	E.	1	E.	3	8 0	......	......	......	......	......	1	1	20 0	121 40	Ship Expounder, 20 feet, grounded at Cleopatra buoy. Got off June 2.
29	3.9	N. E.	3	N. E.	5	6 0	16⅝	2⅜	19	80	1	......	....	12 0	....	
30	3.8	E.	3	E.	5	10 0	16	2¼	18¼	50	......	......	....	....	....	
31	3.8	E.	2	E.	4	8 0	16	2¾	18¾	50	......	1	....	13 0	....	
June 1	3.9	E.	4	E.	2	7 0	16⅝	2⅜	19	90	2	......	....	12 0	....	
2	3.9	E.	2	E.	2	6 0	16⅝	2⅜	19	50	1	1	....	20 0	....	
3	4.0	E.	2	E.	2	11 0	16½	2¼	18¾	90	1	1	....	15 0	....	
4	4.0	E.	1	E.	1	12 0	16¼	2½	18¾	90	3	......	1	21 0	142 0	Ship Lancaster, 21′ 0″; grounded at 9 a. m; got off June 10, at 7 a. m.
5	3.9	S.	2	S.	2	11 20	16½	2¼	18¾	90	......	1	....	10 0	....	
6	4.0	S.	1	S.	1	12 0	16¼	2	18¼	100	3	1	....	15 0	....	
7	3.8	S. S. E.	2	S. S. E.	2	11 0	......	......	......	......	......	2	....	12 0	....	
8	3.8	S. E.	2	S. E.	2	12 0	......	......	......	......	2	2	1	17 8	23 0	Ship John Watt, 17′ 8″; grounded at 7 a. m; got off 6 a. m., June 9.
9	3.9	S. E.	2	E.	2	12 0	17	2⅛	19⅛	90	1	2	....	17 8	....	
10	4.0	N. W.	3	N. W.	3	10 0	17	2¼	19¼	90	......	5	....	21 0	....	
11	4.0	N. N. W.	3	N. N. W.	3	10 0	17	3	20	90	3	4	....	20 8	....	
12	3.9	N. N. W.	2	N. N. W.	2	4 45	17	3	20	100	......	2	1	21 2	*7 0	
13	3.8	N. E.	2	N. E.	3	5 45	17	3¼	20¼	90	......	2	....	15 0	....	
14	4.0	E.	3	E.	3	4 15	17	3¼	20¼	90	......	......	....	....	....	
15	4.0	E.	4	E.	4	......	17	3	20	90	2	2	1	19 0	213 0	Bark Alfa, 19′ 0″; grounded west side of channel; got off June 24.

16	3.8	E. N. E.	2	E. N. E.	2	......	......	......	......	......	3	2	....	15 0	.... ..	
17	3.9	E.	2	E.	3	2 15	17	2½	19½	100	1	2	....	19 10	....	
18	4.0	E.	2	E.	3	8 0	17	2½	19½	100	......	1	....	18 0	....	
19	3.9	E.	2	E.	2	6 30	17	2½	19½	100	......	2	....	20 2	....	
20	3.9	E.	1	E.	1	6 40	17	2¼	19¼	100	3	4	....	17 6	....	
21	3.9	W.	1	W.	2	6 40	17	2¼	19¼	90	......	1	....	17 0	....	
22	4.0	W.	2	W.	2	5 30	16½	2¼	19¼	90	......	2	....	15 0	....	
23	3.9	S. W.	3	S. W.	4	......	......	......	......	......	2	......	1	14 0	....	
24	3.8	S. W.	3	S. W.	2	......	......	......	......	......	......	1	1	20 5	162 0	Steamer Chilian, 20′ 5″; grounded near Cleopatra buoy; still aground June 30.
25	4.0	S. E.	4	S. E.	2	7 0	......	......	......	......	1	1	....	10 0	....	
26	3.9	S. E.	3	S.	2	7 30	15	2½	17½	50	......	......	....	......	....	
27	4.0	S. W.	2	S. W.	1	......	16	2½	18½	50	......	3	....	10 0	....	
28	4.5	S. W.	1	S. W.	1	6 20	16	2¼	18¼	50	......	......	....	......	....	
29	4.8	S. W.	2	S. W.	2	......	16	2	18	50	1	......	....	9 0	....	
30	4.8	S. W.	2	S. W.	1	5 30	16	2	18	60	1	1	....	12 0	....	

*About.

J 2.

IMPROVEMENT OF ENTRANCE TO GALVESTON HARBOR, TEXAS.

This work has progressed during the year under very unfavorable circumstances, arising mainly from retention of the appropriation made for it. Because of this retention, early in July it was found necessary to suspend operations, and it was the middle of September before resumption was made possible, by release of a portion of the money appropriated for the year. Thus the most favorable season for construction was lost, our skilled labor scattered, and plant deteriorated. On resumption, it was thought best to confine operations during those months unfavorable for construction (the winter and spring months) to the collection of material required on the work; to its conversion into the forms used in construction; to the procurement of labor-saving means for such conversion, and for the handling of material; to the repair, preservation, and improvement of the plant provided for the construction parties; to the completion of buildings planned for quarters, workshops, and storehouses, with their out-buildings, cisterns, &c., and to the continuation of surveys.

For information regarding the extent to which this project was carried, reference is made to appended extracts from the annual report of the officer in superintendence, and from the reports of his principal assistants referred to therein. Again, early in January, suspension was forced by lack of means to carry on the work, and resumption made possible in February by release of the balance of appropriation. Since, the work has been carried on without such embarrassment.

The continuance of work during the present year, with the unexpended balance of last year, is being conducted so that should Congress make early appropriation for its further continuance another suspension may possibly be avoided.

The well-known importance of attaining the object for which the work was designed; the fact that the work, so far as completed, has effected the changes at first claimed for it; and the further fact that property, roughly valued at $100,000, is on hand for its continuance, (enough to complete 8,000 feet of gabionade,) will no doubt warrant the early appropriation for the work of the amount hereinafter recommended.

A detailed statement of the work in the manufacturing-yard at Bolivar Point will be found in the extract from the report of Overseer William Lane.

The work for the improvement of the inner bar, after one tier of gabions was carried out to a depth of 23 feet, was suspended (except that for repair of pile pier) to await the building up of the shoal on its Gulf side and the pushing out of the swash-channel about its outer end.

The charts herewith show that the desired results are being obtained.

The work for the improvement of the outer bar was not commenced until the middle of April. It has progressed slowly. Work during the balance of the present season will be mainly confined to it, as it appears unnecessary to further improve the inner-bar channel until an equal depth is provided across the outer bar.

Some exact data on which to base estimate were obtained during the year, and are presented in the report of the officer in superintendence.

The cost of all material on board scows, and ready to be towed to gabionade, may now be stated as follows:

From exact data presented by the officer in superintendence, cost of material on scows, ready for construction, for 1 foot in length of gabionade, 6 feet high and 6 feet wide, is	$8 47
Add for the following items not given, viz:	
Dead-oil in tops, percentage for overseer, foreman, and cooks	45
Total	8 92

This cost of manufacture exceeds my original estimate based on the experimental work at Fort Saint Philip. It greatly exceeds the cost of manufacture as furnished me for presentation in my annual report for 1875, and on which I based a revised estimate for the whole work, yet for reasons which may hereafter appear I shall not submit a new estimate.

When the original estimate was made, as the work was novel in every feature except that of general plan, the only foundation for estimate was that given by the results of experimental manufacture of gabions at Fort Saint Philip; a knowledge of the value of material and labor, and ten months' observation of the conditions presented at the entrance to Galveston Harbor, and due to the winds, waves, and tidal currents which govern the work of construction. The officer in superintendence up to May, 1876, made many changes in construction, approved by me, which enabled him to report a cost less than my original estimate. On the strength of this I reduced estimate.

In the mean time certain questions relating to the work were referred to the Board of Engineers detailed to consider the original project, and it was suggested (suggestion not embodied in report) that the gabions should be made stronger, the methods to be left to the discretion of the engineer in charge. It was also recommended that mats be placed underneath, at the sides, and in front of the gabionade to prevent settlement and scour in advance.

Compliance with these recommendations has increased the cost of manufacture, but, at the same time, while the additions made to the gabions themselves have perhaps unnecessarily added to their strength, the saving in settlement from use of mats has been such as to make two rows of gabions, and in places one row, answer the same purpose as the several rows provided for in the original design.

This is a partial offset to increased cost of manufacture. It now appears probable, judging from effects produced by the inner-bar work, that the Bolivar gabionade need not be carried out so far as the outer-bar crest to produce every desirable result—perhaps a gabionade 2½ or 3 miles in length will answer, and for this we have provided for about 8,000 feet.

The cost of construction must vary considerably from year to year; no good approximation can be offered. All things considered, I think it best to hold to my last estimate.

I beg leave to again respectfully represent in official report that I am convinced, from such experience as I have had, that if any work of river or harbor improvement is worth undertaking it should be provided for by adequate and timely appropriation. This work of which I report is no doubt one of importance, and to enable the engineer intrusted with its conduct to carry out his approved plans with the greatest credit to himself and the least cost to the United States it is no doubt desirable, at least so long as the work is continued at the expense of the United States, to have it conducted in the most economical manner.

This cannot be done so long as the recommendations of the engineer in charge, as to amount of appropriation for each year, are partly disregarded and appropriation based less on these recommendations than on considerations foreign to the work.

The recommendation this year is that the balance of estimate, $207,740, be appropriated for the work. This amount is more than will be required for the present fiscal year. It will be enough to provide for conduct of the work during the next fiscal year.

It cannot safely be said that it will be enough to complete the work, but, by having it available so that suspensions may be avoided, it will come nearer effecting completion than if appropriated in driblets.

When my last annual report was written it was thought that the work might be let out at contract. It was thought that as an experiment it had progressed far enough to furnish reliable contractors with data for making intelligent bids.

Withholding of appropriation made it necessary to continue the work by day's labor and purchase in open market, as the means for this were placed at command.

From the experience gained during the past year, I now think it advisable to recommend that the work of manufacture be continued as heretofore, inasmuch as at least a three months' supply must be always kept, for the purpose of fully seasoning, in advance of construction, and as the increased exposure of the gabionade as it progresses toward the crest of the outer bar may necessitate addition, to secure desirable strength, the character and cost of which addition can only be ascertained after they are found necessary, and inasmuch as it would be a difficult matter to provide in specifications for possibilities in such exact terms as to prevent claim for extra labor and expense on the part of contractors.

I think there is a greater certainty of having this branch of the work well done under the present system (and as cheaply done) than if contracted for. It is different with the work of construction; this can be covered by exact specifications, and the contractor left to battle with all the conditions adverse to construction in his own way, at his own risk, and with such plant as the work now offers for this purpose, together with such other as he may see fit to add at his own expense.

Should Congress make further and adequate appropriation, and this be made available, I will make recommendation as suggested above.

The collector of the port of Galveston has courteously furnished the following commercial statistics:

At this port during the year from July 1, 1276, to June 30, 1877, there was collected $94,575.46, and of this amount the duties on merchandise received in bond amounted to $2,185.76.

Vessels.	Entries.		Clearances.	
	No.	Tons.	No.	Tons.
American, coast	387	406, 993	301	263, 792
American, foreign	51	22, 371	46	21, 234
Foreign	115	77, 015	104	71, 791
	553	506, 379	451	356, 817

Value of exports shipped to foreign countries during the year ending December 31, 1876, $14,877,141.

The work is located in the collection-district of Galveston, and the nearest light-house is that on Bolivar Point.

Original estimate	$1,259,446 43
Revised estimate	559,740 00
Whole amount appropriated	352,000 00
Whole amount expended	307,935 47

Money statement.

July 1, 1876, amount available	$18,749 98	
Amount appropriated by act approved August 14, 1876	142,000 00	
		$160,749 98
July 1, 1877, amount expended during fiscal year	116,685 45	
July 1, 1877, outstanding liabilities	8,011 93	
		124,697 38
July 1, 1877, amount available		36,052 60
Amount (estimated) required for completion of existing project		207,740 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		150,000 00

EXTRACT FROM REPORT OF LIEUTENANT C. E. L. B. DAVIS, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Galveston, Texas, July 2, 1877.

SIR: I have the honor to submit the following report of operations for improving the harbor of Galveston, Texas, for the year ending June 30, 1877.

On July 10, 1876, I received telegraphic instructions from you to suspend work immediately, the balance of the appropriation being barely sufficient to pay outstanding indebtedness; to retain Messrs. Ripley and Talfor, assistant engineers, and such employés as might be necessary to properly care for public property; also, to go to New Orleans, for consultation with you, as soon as the condition of the work would permit me to do so.

On September 2, being at that time in New Orleans, I received orders from you to proceed to Galveston, Texas, and resume the superintendence of the work for improving the harbor at that place. On the 11th of the same month you telegraphed me from Washington to go ahead with the work.

I put on a force of 72 men, and resumed the manufacture of gabions and the collection of material for the construction of the gabionade; also the construction of new buildings for office, draughting-room, and quarters of the assistant engineers.

Everything was progressing favorably up to January 8, 1877, when, in obedience to verbal instructions from you, I commenced reducing the force of men very materially, and the remainder of the month was passed in completing the partially constructed gabions.

From the 5th to the 12th of January, as the sand-dredge had just been completed, a commencement at sinking gabions was made. During that time 7 gabions were placed in position in the gabionade at Fort Point. (See special report, dated January 20, 1877.)

On January 12 I received a copy of a letter addressed to you from the Chief of Engineers, stating that the Secretary of War had disapproved your application that the balance of the appropriation be made available by the first of February. I therefore deemed it best to suspend work, as the amount on hand was insufficient to carry it on.

During the month of January an unsuccessful attempt was made to repair the breaks in the outer end of the Fort Point breakwater, by fastening fascine mats vertically against the piling, spiking a piece across the top of the mat to the string-pieces of the piles and weighting the loose end of the mat with concrete-blocks, but the constant swell caused by the race of the tides gradually tore the fastenings and the first storm destroyed the mats.

On February 22 telegraphic instructions were received from you to resume work again, as the balance of the appropriation had been made available. Work was at once resumed and a large force of men employed, and since that time the work has been pushed forward as rapidly as possible.

REPAIR OF BREAKWATER AT FORT POINT.

The palmetto piles, ordered from Pensacola by sail, were a long time delayed by adverse winds, so that repairs on the breakwater were not commenced until March, 1877. At first the sand-dredge was used for pumping down the piles, but on the 27th of the month a 2-inch Blake pump was received from you, and since that time has been constantly at work.

Much delay was caused by our meeting with many obstructions, such as the stumps of old piles, bags of concrete, etc., which all had to be removed to make room for the new piling.

A layer of finely-compacted shells, the cementing material being very dark, and resembling asphalt, was met with, which was quite a serious obstruction.

It lay about 5 feet below the surface of the sand, was 2 feet in thickness, and extended a distance of 75 feet along the breakwater, and was very difficult to penetrate with a palmetto pile.

The piles varied in length from 18 to 24 feet, the former being put down at the inner end in about 4 feet of water, and the length gradually increased as deeper water was reached.

The heads of the piles were secured between two waling-pieces, the outside of 4″×8″ lumber, and the inside 2″×6″, the latter being added for the reason that the palmetto is too soft to give a good bearing-surface for the nuts and washers of the iron bolts.

Just above low-water is another piece of 4″×8″.

Every 8 or 10 feet caps of 4″×8″ are spiked to cap-piles.

Up to June 30, 1877, 868 feet of the breakwater was completed, 624 feet being entirely new.

There were used in this work of repair during the year ending June 30, 1877, 786 palmetto piles, 1,600 ⅞-inch iron bolts, 6,700 feet (board-measure) of lumber, 135 barrels of coal, and 145 barrels of fresh water.

GABIONADE AT FORT POINT.

In this gabionade 81 gabions were sunk in all, including the 7 sunk in January. Under 36 gabions were placed 9′×12′ mats, and under 38 gabions mats 12′×12′, these mats being made of fascines. The 7 put down in January had under them the light cane mats used by Lieutenant Quinn.

Thirty-four 9′×12′, and 54 6′×12′ wing-mats were put down on the channel-side; these wing-mats being securely fastened to the mats under the gabions by galvanized iron wire, and weighted with concrete blocks and sand-bags. These mats were put in position by a diver.

The gabions were placed in position between a double row of guide-piling, 144 piles being driven for that purpose. Eight hundred and seventeen concrete blocks and 100 sand-bags were used in the construction of this gabionade.

The weather was very unfavorable for working the greater part of the time. The pilots report that the inner bar has been remarkably rough during the entire spring and early summer. Between April 4 and June 20 there were 34½ days in which it was impossible to do any work whatever. Owing to the nature of the bottom, difficulty was experienced in filling the gabions with the sand-dredge. In several cases it took from 2 to 3 hours to fill 1 gabion.

The last 2 gabions placed at Fort Point, in about 23 feet of water, had to be filled by shoveling sand from the deck of a barge, as the bottom was a dark blue clay, which could not be raised by the pump. The sand was shoveled into a hopper leading into the gabion filling-hole, 5 men shoveling and 1 playing an inch and a half stream of water to keep the chute from choking. It took about 3 hours to fill these 2 gabions.

The gabions have been located by Mr. Ripley and partly from time to time, and a tracing appended herewith and marked "A" shows the plan and elevation of this gabionade, and when possible the lateral inclinations of the gabions. The total length constructed during the year was 1,000 feet.

BOLIVAR POINT GABIONADE.

On April 14 a commencement was made on the sheet-piling of this work, which was to run out to water deep enough to sink gabions.

It consisted of a double row of pine piling, properly capped and braced with 3-inch sheet-piling on the seaside. It was run out a distance of 513 feet, and up to the 30th of June 393 feet of the sheet-piling had been driven.

On the 21st of June I commenced putting gabions down in 6 feet of water, at mean high tide, on the continuation of the line of piling.

On June 30 14 gabions had been placed in position and filled, making a total length of 172 feet. These gabions were sunk on the bottom without mats, in order to allow them to settle. They have settled about 19 inches thus far, and have settled quite evenly.

The gabions were filled by barrows from the shore, run out on plank laid on the piling of the breakwater and the guide-piles of the gabions, as the bottom was muddy, with only a thin crust of sand on top. The accompanying tracing marked "B" shows the sheet-piling, piling, and gabions at Bolivar Point on the 30th of June.

The only accident of note that occurred during the season was the loss at Fort Point on June 9, 1877, of 10 gabions with their trucks, owing to the gabion-barge getting into the trough of a heavy sea while lying at anchor in Galveston Channel, and swinging around to a sudden change of a high wind. Subsequently 7 of the trucks were recovered.

CONSTRUCTION-GROUND AT BOLIVAR.

At the construction-grounds at Bolivar there were built during the year—

One two-story building, 30 feet by 25 feet, officers' quarters.
One two-story building, 30 feet by 25 feet, officers' quarters.
One two-story building, 13 feet by 20 feet, kitchen.

One one-and-a-half-story building, 15 feet by 40 feet, storehouse.
One one-and-a-half-story building, 30 feet by 60 feet, machine-shop.
One one-story building, 12 feet by 12 feet, store-house.
One one-story building, 10 feet by 10 feet, temporary tool-house at Bolivar Point gabionade.
One tide-gauge house for self-recording tide-gauge and anemometer.
Three pile-drivers, 4 cisterns, 1 carbolizing-tank, 12 feet 6 inches by 6 feet 4 inches and 6 feet deep.

The following statement shows the number of gabions completed during the year:

Gabions on works (completed) September 13, 1876	243
Gabions constructed up to date, June 30, 1877	543
Total	786
Gabions placed in Fort Point gabionade	81
	705
Gabions placed in Bolivar Point gabionade	14
	691
Gabions washed off scow and lost (June 9, 1877)	10
Gabions on works completed June 30, 1877	681

MATERIAL IN 10 GABIONS.

Yellow-pine lumber, 3,253 feet 4 inches, at $18	$58 56
Iron bolts, 205 pounds, at 2¾ cents	5 64
Nuts and washers, 8½ pounds, at 7½ cents	64
Nails, assorted, 107½ pounds, at 0.34 cents	3 65
Bundles cane, 450, at 35 cents per 100	78 75
Cement, 48 barrels, at $1.65	79 20
Sand, 121 barrels, at 9 cents per cubic foot	43 56
Brick, 54 barrels, at 9 cents	19 44
Gravel, 27 barrels, at 9 cents	9 72
Galvanized-iron wire, 17 pounds, at 8 cents	1 36
Stakes, pine, 7 feet long, 400, at 3 cents	12 00
	312 52

MATERIAL IN 10 MATS.

House-line, 30 pounds, at 18 cents	5 40
Nails, 2½ pounds, at 0.34 cents	85
Galvanized-iron wire, $21\frac{9}{16}$ pounds, at 8 cents	2 13
Bundles of cane, 330, at 35 cents per 100	57 75
Marline, 18¾ pounds, at 18 cents	3 37
	69 50

MATERIAL IN 10 CONCRETE BLOCKS.

Cement, ⅚ barrel, at $1.65	1 38
Sand, 1⅔ barrels, at 9 cents	15
Gravel, 5 barrels, at 9 cents	45
	1 98

MATERIAL IN FASCINES FOR 10 GABIONS.

Cane, 40 bundles, at 35 cents per 100	7 00
Marline, 10 pounds, at 18 cents	1 80
	8 80

LABOR ON THE ABOVE MATERIAL.

Carpenters' time on 10 gabions, 120 hours, at 25 cents	30 00
Wattlers' time on 10 gabions, 150 hours, at 15½ cents	23 25
Plasterers' time on 10 gabions, 98 hours, at 15½ cents	15 19
Laborers' time on 10 gabions, 273 hours, at 11½ cents	31 40
Sawing 400 stakes, 9 hours, at 11½ cents	1 04
Sharpening 400 stakes, 27 hours, at 11½ cents	3 11

Staking 10 bottoms, $6\frac{7}{10}$ hours, at $15\frac{1}{2}$ cents	$1 04
Trimming cane, 60 hours, at $11\frac{1}{2}$ cents	6 90
Loading gabions on cars and scow, 87 hours, at $11\frac{1}{2}$ cents	10 01
Loading mats and concrete blocks, 78 hours, at $11\frac{1}{2}$ cents	8 97
Making fascines for 10 mats, 275 hours, at $11\frac{1}{2}$ cents	31 63
Making 10 mats, $64\frac{1}{2}$ hours, at $11\frac{1}{2}$ cents	7 42
Total	169 96
Add 90 days' board, at 42 cents	37 80
Total	207 76

* * * * * * *

I transmit herewith the report of Assistant Engineer H. C. Ripley of the survey-work done during the year ending June 30, 1877. I also forward tracings marked "A" and "B," referred to in the body of the report; one marked "C," showing the positions of both gabionades, and a tabular statement showing amount of work done during the year.

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Very respectfully, your obedient servant,

CHAS. E. L. B. DAVIS,
First Lieutenant of Engineers.

Capt. C. W. HOWELL,
Corps of Engineers, U. S. A.

REPORT OF MR. H. C. RIPLEY, ASSISTANT ENGINEER.

GALVESTON, TEXAS, *July 4*, 1877.

DEAR SIR: I have the honor to submit the following report of surveys connected with Galveston Harbor improvement for the year ending June 30, 1877:

The hydrographic work has been mostly confined to surveys of the inner bar. The monthly surveys were omitted for July, August, January, and February, on account of suspension of work, and for October on account of absence at Sabine Pass.

The following table shows the greatest depth that could be carried across the inner bar at the time of each monthly survey.

DEPTH ON INNER BAR AT MEAN LOW TIDE.

Time of survey.	Depth in feet.
September, 1876	$15\frac{3}{4}$
November, 1876	$16\frac{1}{4}$
December, 1876	16
March, 1877	$16\frac{1}{4}$
April, 1877	$16\frac{1}{4}$
May 1877	$16\frac{1}{4}$

The survey for June has been made, but the work is not yet plotted.

It will be observed that very little change has occurred on the inner bar, and that a constant depth of $15\frac{3}{4}$ feet or more has been maintained throughout the entire year, the survey for June, 1876, having shown a depth of $16\frac{1}{2}$ feet.

GABIONADE.

The positions of the gabions of the Fort Point gabionade have been located from time to time as the work progressed. A tracing herewith accompanying shows a plan and elevation of the gabionade and also the lateral inclination of the gabions where the water was not too deep to prevent its determination.

The total length constructed during the year is 1,000 feet, and the number of gabions 80. Between the 6th and 30th gabions Mr. Hanlon's count shows one more gabion put down than I have located. Such being the case, it must have drifted out of line and been replaced by another, for there is not room for more than are shown; and these were located at each end so that it would be hardly possible to miss one without making the discovery when the work was plotted.

The Bolivar Point gabionade and sheet-pile jetty have been located and are shown on the tracing accompanying.

The length of sheet-piling completed is 393 feet.

The length of auxiliary piling with cross-ties is 513 feet. The total length of gabionade is 172 feet, containing 14 gabions.

The gabions are so nearly level, and having been recently put down and not yet settled, I did not attempt to show their inclinations, and, not yet having the mean low water

of the gauge at that point established, I could not show their depth from the water-surface, but their tops are not much, if any, below the water-surface of mean low tide.

At the time of the commencement of work on the Bolivar sheet-pile jetty, soundings were taken on the line of the proposed gabionade, so that this profile compared with any future one on the same line will show exactly what change has taken place.

TIDE-GAUGES.

A record of the hourly readings of the tide-gauge at the wharf, Bolivar Point, has been kept during continuance of the work. Tide-gauges have also been kept at Galveston, Fort Point, and Bolivar Point jetty when necessary for the reduction of soundings.

The self-registering tide-gauge and anemometer are in satisfactory operation. The gauge has been working for three months past and the anemometer for the past month.

I have been assisted during the year by Mr. R. B. Talfor, assistant engineer. The monthly survey of the inner bar for September was made by Mr. Talfor during my absence.

Very respectfully, your obedient servant,

H. C. RIPLEY,
Assistant Engineer.

Lieut. C. E. L. B. DAVIS,
Corps of Engineers, U. S. A.

Extract from report of Mr. William Lane, overseer.

CONSTRUCTION OF BUILDINGS.

Constructed one two-story building, 30′ by 25′; officers' quarters. One two-story building, 30′ by 25′; officers' quarters. One two-story building, 13′ by 20′; kitchen. One one-and-one-half-story building, 15′ by 40′; store-house. One one-and-one-half-story building, 30′ by 60′; machine-shop. One one-story building, 12′ by 12′; store-house to new quarters. Two one-story temporary tool-houses, 10′ by 10′, at Bolivar Point breakwater. One tide gauge-house at Bolivar Point. Four cisterns. One dead-oil vat, 12′ 6″ by 6′ 4″ wide, and 6′ deep. One book-case for office. One desk for office; 1 wash-stand. One shelf and 1 table for new quarters, and 4 benches for mess-room. Three pile-drivers and 1 refrigerator.

CONSTRUCTION OF GABIONS.

323	gabion-bottoms made.
471	gabion-tops made.
960	gabion-frames made.
467	gabion-bottoms staked.
495⅞	gabions wattled.
469	gabions ballasted.
531	gabions plastered inside.
490	gabions first-coated outside.
543	gabions second-coated outside.
826	gabion-bolts made.
396	gabion-tops carbolized.
398	gabion-tops nailed on.
6	gabion-bottoms carbolized.
273	gabion-tops coated with plaster.
543	gabions completed from September 13, 1876, up to June 30, 1877.
43,820	bundles cane trimmed.
1,786	batches mortar made.
462	batches ballast made.
10,072	fascines made for mats.
2,133	concrete blocks made.
199	mats made, 6′ by 12′, (of fascines.)
102	mats made, 9′ by 12′, (of fascines.)
171	mats made, 12′ by 12′, (of fascines.)
148	batches concrete made for blocks.
208	sand-bags made at Bolivar Point.
88	gabions were stripped of frosted plaster and renewed.
1	catamaran made for gabionade.
470	sheet-piling were pointed.
849	palmetto piles pointed and butted.

145 pine piles pointed and butted.
6,593 cubic feet of brick broken for concrete.
544¾ feet of tin gutter made and put up on buildings.
337½ feet of tin conductor made and put up on buildings.
355 bolts were made for tug.
2 tide-gauge boards made.
1 sounding-pole made.
1 galvanized-iron pump made for well.
2 pumps made for scows.
46 iron boxes were made for cars.
4 brass boxes were make for cars.
2,258 barrels of cement used in constructing gabions.
5,698 barrels of sand used in constructing gabions.
756 barrels of gravel used in constructing gabions.
1,870 barrels of br'ck used in constructing gabions.
148 barrels cement }
298 barrels sand } used in making concrete blocks.
888 barrels gravel }

Construction of gabionade at Fort Point.

81 gabions placed in gabionade.
180 guide-piles were driven in gabionade.
110 mats, 12′ by 12′, placed in gabionade.
20 mats, 9′ by 12′, placed in gabionade.
31 mats, 6′ by 12′, placed in gabionade.
113 sand-bags, 45 fascines, 906 concrete blocks.
972 linear feet of gabionade completed.

Construction of gabionade at Bolivar Point.

14 gabions placed in gabionade.
22 guide-piles driven at gabionade.
168 linear feet of gabionade completed.

Construction of breakwater at Bolivar Point.

238 pine piles driven, 366 sheet-piling driven.
515 linear feet of piling completed.
315 linear feet of sheet-piling completed.

REPAIRS OF BREAKWATER AT FORT POINT.

823 palmetto piles were driven.
6 mats were sunk in repairing breakwater.
34 concrete blocks used for weighting mats, 118 gabions, 77 mats 12′ by 12′, 58 mats 6′ by 12′, 78 mats 9′ by 12′, 319 pine piles, 1016 concrete blocks, 132 fascines, 940 palmetto piles, 50 bags filled with sand, 272 barrels of coal, 1 cord of fire-wood, and 25 pieces of yellow-pine lumber, were loaded on scows and towed by tug to gabionades and breakwater.

Forty-four thousand six hundred and seventy-five feet, b. m., of yellow-pine lumber, 28,600 shingles, 7,000 hard brick, 1,100 barrels cement, 100 barrels dead-oil, 1 barrel coal-tar, 1 barrel lard-oil, 1 barrel lubricating-oil, 356 palmetto piles, 6,500 laths, 2 bales oakum, 521 pounds sheathing-paper, 265¾ tons coal, 426 pounds galvanized sheet-iron, 4,954 feet, b. m., cypress, 2,011 pounds round iron, 1,055 feet of ceiling, and 2,998 feet of dressed flooring were loaded on scows at city, towed by tug to works at Bolivar Point, and unloaded.

Seven hundred and fifty-four pine piles, 13,827 pine stakes, 472,560 feet, b. m., of yellow-pine lumber, 2,198 feet of cypress, 30,700 shingles, 6,000 laths, 2,624 pounds of tramway-iron, 4,265 pounds of round iron, 1,399,700 cane, 1,184 palmetto piles, 2,810 barrels of cement, and 21½ cords of wood were unloaded from vessels, hauled up, stored, and piled on works.

Nine thousand one hundred and ninety-three and five-sixths cubic feet of gravel, 9,925½ cubic feet of brick-bats, 22,570 hard brick, and 7,382⅝ cubic feet of sand were hauled up from wharf and stored on works.

Eight thousand eight hundred pounds nails, 30 barrels cement, 1 barrel dead-oil, 625 feet of lumber, 5,753 pounds of iron, 10,000 shingles, 1,330 feet of dressed lumber, and 1,003 pounds of galvanized iron were loaded on tug at city, transported to works, unloaded, hauled up, and stored on works.

REPAIRS OF BOATS.

Tug.

Hauled out on ways, overhauled, and cleaned boiler, calked crack in front of fire-box between rivet and lap, took down bonnet of steam-chest, and repaired steam-valve. Put 2 new planks in bottom, made new rudder-stop, refastened rudder-blade, nailed 6 sheets yellow metal on bottom, took down bulkhead, put down floor in lower engine-room, set graving-pieces in keelson, made new oak shoe, one fore and aft beam, 18 feet long. Put in new bulkhead between galley and boiler-room, put piece of oak in stern, put 3 pieces oak in guards, put 2 new pieces deck-plank in, put new oak knee in arch aft, over propeller, put in new floors to bunkers, made and fitted pillow-blocks to condenser, fitted side-sheets to ash-pan of boiler, put in floor under condenser, fitted shaft of propeller, fitted main journal brasses, put in new pump, put in condenser and connections, connected up donkey-pipes to condenser and surplus-feed and exhaust to donkey-pump; packed circulating pump.

Launch.

Hauled out on ways, ground in cylinder of steam-chest, packed engine, and general cleaning of machinery, put up pump lead, stand for heater, put in new beam, put in new bulkhead, put in 2 pieces boiler-bed, put in supply-pipe strainer on outside, fitted up pony pump and heater, constructed new boiler, painted same, old boiler taken out, new one put in, connected pipe with machinery, painted hull inside and out, fitted iron braces from boiler to saddles, braced fire doors, &c., connected up feed-pipe, repaired steering-wheel, put soapstone lining in back connection of boiler, covered boiler with wool-back felting and sheet-lead, 1 galvanized iron fender made.

Diver's flat.

Hauled out, bottom calked and tarred.

Sand-dredge.

Hauled out, calked, papered, sheathed, and tarred the bottom, repaired rudder; machinist overhauled and cleaned machinery; calked and painted decks, put in 4 angle-knees, cut in chocks to partner of derrick and samson-post, repaired boiler, one iron jacket and umbrella made, and put on smoke-stack with 2 iron plates.

Yawl-boats.

One painted inside and out, bottom repaired and calked all over, 6 new timbers put in, 2 pieces plank put in, 1 new seat put in, recalked, 2 stiffening-bolts put in and painted, 8 new timbers put in, new keel put in, 2 new cross-pieces, 13 timbers, 6 new planks put in bottoms, 17 new timbers put in, calked bottoms, coppered stern, and put in 4 new sets of timbers.

Barge No. 1.

Hauled out on ways and undergoing repairs.

* * * * * * *

EXTRACT FROM LETTER OF LIEUTENANT C. E. L. B. DAVIS, CORPS OF ENGINEERS, DATED JULY 16, 1877.

* * * * * * *

I have the honor to transmit herewith the regular monthly chart of the inner bar of Galveston Harbor for the month of June, 1877.

A comparison of this chart with the last shows the effect of the Fort Point gabionade quite plainly. The 12-foot contour line has moved outward about 200 feet, while the 18-foot contour has advanced about 150 feet. This effect appears to be still going on, and I think this month's chart will show a still greater change.

* * * * * * *

J 3.

CONTINUATION OF THE WORK ON THE SHIP-CHANNEL IN GALVESTON BAY BETWEEN RED-FISH BAR AND MORGAN'S POINT.

The last appropriation for this work, $72,000 in amount, was made available April 25, 1877, but as the exact location of channel has not been determined upon, (see my report on survey for ship-channel, &c.,)

no work was undertaken during the year. As soon as the question of location is decided it is proposed to offer the work at contract in the usual manner.

The following project was submitted under date of May 21, 1877, in response to order of the Chief of Engineers, United States Army:

* * * * * * *

It is proposed to expend the appropriation, under contract, for dredging a channel 12 feet in depth at mean low tide and 100 feet in width at bottom along such line as may be selected by the Chief of Engineers. If the line direct from Red-Fish-Bar Channel to Morgan's Canal be adopted, then the dredging to be commenced at the upper end of the channel and continued toward Red-Fish Bar until the appropriation is exhausted, the reason being that this portion of the line lies through the shoalest portion of the bay.

In case a line to the mouth of the San Jacinto River be selected, then it is proposed to commence the work by excavating a channel through Clopper's Bar and protecting it by piling, as set forth in my report of survey just forwarded, and as laid down on the chart accompanying it. This work to be done by contract. It is proposed to request bids—

1. For removal of material dredged to a distance from the channel, in scows.
2. For placing material on the side of cut, and at a distance from it of not less than 60 feet. All measurements to be made in cut, and no allowance for depths greater than 12 feet or width at bottom greater than 100 feet.

It is desirable to begin the work as soon as possible, as the most favorable season for work of this kind is passing away.

Very respectfully, your obedient servant,

C. W. HOWELL,
Captain of Engineers.

As shown in my report of survey, the cost of a channel from Red-Fish Bar to the cut through Morgan's Point would be less than the cost of one to connect with the San Jacinto River, and crossing the bar at its mouth. Yet if this Morgan's Point cut had not been made, the other route would have been the cheaper, and perhaps the more desirable. The objection to making the channel terminate at the Morgan Point cut is that this cut is private property, and tolls are charged for its use. This objection is one of such importance that the Hon. Secretary of War has decided to leave the question it presents to the decision of Congress, as shown by the following letter from the Chief of Engineers:

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., June 12, 1877.

SIR: Your letters of the 21st ultimo, one submitting a project for the expenditure of the appropriation of $72,000, made by the river and harbor act of August 14, 1876, "For the continuing of the work on the ship-channel in Galveston Bay," &c., "to be expended between Red-Fish Bar and Morgan's Point, Texas;" the other submitting report on the survey for a ship-channel through Galveston Bay, Texas, have been received.

Your letters were submitted by the Chief of Engineers to the Secretary of War with a communication, which has been approved by him, and from which the following extract is furnished for your information and guidance:

"In the project now submitted by Captain Howell for the expenditure of the appropriation of $72,000, he designates three lines upon which a dredged channel of 12 feet may be made.

"But the expenditure of this appropriation upon any one of these lines will be to that extent an anticipation of the decision of Congress upon the results of the survey they have ordered to be made and reported to them. Besides, the act, in the section directing the survey, looks to a channel running out of the mouth of the river, instead of through the cut of Morgan's Point, although the estimated cost of the latter is nearly $200,000 less than the cost of the least expensive of the other two.

"The question of tolls, however, is involved in using the Morgan's Point canal-route.

"It seems to me advisable, under these circumstances, to defer a decision upon which of these lines the appropriation for continuing the work on the ship-channel should be expended, until the final report upon the survey is made and the future action of Congress thereon is known. The most favorable season for work of this kind is now passing away."

The expenditure of the appropriation of $72,000 for continuing the work on the ship-channel in Galveston Bay, &c., will accordingly be deferred until further orders.

By command of Brig. Gen. Humphreys.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Major of Engineers.

Capt. C. W. HOWELL,
Corps of Engineers.

The question of location was the one which, I understand, was to be settled on the data to be furnished by this survey.

This question I would recommend be referred to a Board of Engineers for settlement.

The work is located in the collection-district of Galveston, near the light-house on Red-Fish Bar, and cannot be considered as one of permanent character.

Whole amount appropriated	$97,000 00
Whole amount expended	25,000 00

Money statement.

Amount appropriated by act approved August 14, 1876	$72,000 00
July 1, 1877, amount available	72,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	150,000 00

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., June 8, 1877.

SIR: I beg leave to submit for your consideration the accompanying project received from Captain Howell, Corps of Engineers, for the expenditure of the appropriation of $72,000 in the river and harbor act of August 14, 1876, "For continuing the work on the ship-channel in Galveston Bay, to be expended between Red-Fish Bar and Morgan's Point."

The same act (section 2) appropriates $10,000 for a survey for a ship-channel through Galveston Bay, "beginning at 12 feet water in the mouth of San Jacinto River, and running out of the mouth of that river east of Morgan's Point to the present channel, through Red-Fish Bar," &c. This survey is not quite completed, but its results are expected in time to be submitted to Congress with the next annual report of this office.

The work on the ship-channel above alluded to is that done under the appropriation of $25,000, of March 3, 1875, which was completed, as far as the appropriation admitted, February, 1876. It connects depths of 9 and 8½ feet in the upper and lower bays, and, with the private work of improvement at Morgan's Point, permits the passage of vessels of 9-foot draught to within a few miles of Houston. Tolls are charged by the proprietor for the passage of vessels through the cut at Morgan's Point.

The officer in charge recommended in his last annual report that further appropriation be applied to making a 12-foot channel in extension of the above channel, and that its upper terminus be made at the cut through Morgan's Point, instead of at the mouth of San Jacinto River. This recommendation was concurred in, at the time, by this office.

In the project now submitted by Captain Howell for the expenditure

of the appropriation of $72,000, he designates three lines upon which a dredged channel of 12 feet may be made. But the expenditure of this appropriation upon any one of these lines will be to that extent an anticipation of the decision of Congress upon the results of the survey they have ordered to be made and reported to them. Besides, the act, in the section directing the survey, looks to a channel running out of the mouth of the river, instead of through the cut of Morgan's Point, although the estimated cost of the latter is nearly $200,000 less than the cost of the least expensive of the other two. The question of tolls, however, is involved in using the Morgan's Point canal-route.

It seems to me advisable, under these circumstances, to defer a decision upon which of these lines the appropriation for continuing the work on the ship-channel should be expended, until the final report upon the survey is made and the future action of Congress thereon is known. The most favorable season for work of this kind is now passing away.

I also transmit herewith a report from Captain Howell, dated May 21, 1877, showing the progress of the survey in Galveston Bay, and a sketch, prepared in this office, of the locality, with the proposed lines of cut.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brig. Gen. and Chief of Engineers.

Hon. GEO. W. MCCRARY,
Secretary of War.

[Indorsement.]

Approved:
June 9, 1877.

GEO. W. MCCRARY,
Secretary of War.

J 4.

SURVEY FOR A SHIP-CHANNEL THROUGH GALVESTON BAY, TEXAS.

This survey was provided for by the following clause in the river and harbor bill passed by the 44th Congress of the United States during its second session:

SEC. 2. That the Secretary of War is hereby directed to cause a survey for a ship-channel through Galveston Bay, beginning at twelve-feet water in the mouth of the San Jacinto River and running out of the mouth of said river east of Morgan's Point to the present channel through Red-Fish Bar; thence through the same, extending through Galveston Harbor, passing west of Half-Moon Shoals and Pelican Island and to twelve-feet water in Galveston Channel; and to cause an estimate of the cost of the same to be made, and of the comparative merits of the same with the route to the head of Bolivar Channel, and of the effects of the completion of each of said channels on the Galveston Harbor as to shoaling or deepening the same, and report the same to Congress by the first day of December, eighteen hundred and seventy-six, the cost thereof not to exceed ten thousand dollars, to be paid out of the forty thousand dollars hereinafter appropriated. * * * * *

The survey of the upper bay having been completed in advance of that of the lower bay, and as an appropriation for the dredging of a ship-channel through this portion was available and its application dependent upon such recommendation as the results of survey might suggest, the following preliminary report was forwarded under date of May 21, 1877:

NEW ORLEANS, LA., *May* 21, 1877.

GENERAL: I have the honor to forward herewith the report of J. A. Hayward, assistant engineer, charged with the primary triangulation for survey for a ship-channel through Galveston Bay, Texas, and with the hydrographic work in the upper bay. The work for the upper bay is plotted on two sheets, tracings of which accompany this report.

Report is submitted at this time, without waiting for completion of the lower-bay work and index-chart, because of instructions contained in Engineer Department letter of April 25, 1877, calling for a project for expenditure of $72,000 appropriated by Congress in the river and harbor act of August 14, 1876, "for the continuing of the work on the ship-channel in Galveston Bay," the money to be expended between Red-Fish Bar and Morgan's Point.

On the charts presented three lines are laid down, and in the report of Mr. Hayward estimates are submitted for each for channel 12 feet in depth at mean low tide and of widths of 100 feet, 150 feet, and 200 feet.

If decision as to choice of line to be adopted for the channel is to be based mainly on amount of excavation to be made, it is evident that the line from Red-Fish Bar to the cut through Morgan's Point is by far the most advantageous.

The line "A I" the next, and the line "A D" the least. (See Hayward's report and charts.)

Very respectfully, your obedient servant,

C. W. HOWELL,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

REPORT OF MR. J. A. HAYWARD, ASSISTANT ENGINEER.

GALVESTON, TEXAS, *April* 30, 1877.

SIR: I have the honor to make the following report on that portion of "survey of ship-channel through Galveston Bay, Texas," intrusted to my charge:

* * * * * * *

The soundings are all reduced to mean low-water of the Gulf of Mexico, as indicated by the Bolivar Point gauge.

Tide-gauges were kept at Red-Fish light-house and in Morgan's Canal at Morgan's Point. The readings of these gauges for mean low-water were determined by a careful comparison with the readings of the Bolivar gauge of the high and low water of the same tides, and a mean of the general result taken in each case. When the appropriation already made for this work is expended, I would suggest that this plane of reference be retained. For while the summer tides average about a foot above this plane, the winter tides are often from one-half a foot to 1 foot below it for several days at a time. And this low-water occurs at the very time there is the greatest need of deep water, as by far the greatest portion of freight by this line is carried during the winter months, the season of low tides.

Per your verbal instructions, the survey was extended to cover Morgan's Cut, already made, and continuation of the same to Red-Fish Reef. This has enabled me to show the exact condition of that work, and give some idea as to its probable permanence.

It has also enabled me to show, as completely as possible, the respective merits of each of the proposed routes.

The work has been plotted to a scale of one-ten thousandth, as shown on charts Nos. 1 and 2. An index-chart to a scale of one-forty thousandth has also been made, showing all of the bay in question from 12 feet water in the San Jacinto River to 12 feet water in the Gulf of Mexico, and location of the various proposed lines. The following are the cuts proposed:

From 12 feet water at A, San Jacinto Bay via the curve, as shown by the red line from that point to B, and thence via a straight line tangent to this curve to 12 feet water in Bolivar Channel, shown at E, index-chart. This line I have estimated upon to the point D.

A second proposed cut runs from A to B, and thence to H, at the head of the dredged channel through Red-Fish Reef; then through this channel, as shown on the index-chart. I have estimated this line to the point J in this cut.

A third estimate has been made over the route as cut by Morgan from the point F to G through Morgan's Point; thence from G to H, and then through the cut as before.

The total estimated cost over each of these routes is as follows:

ROUTE FROM A TO D.

Excavation in cubic yards for given base.—Slope 2 to 1.

	12 feet deep.		
	100 feet base.	150 feet base.	200 feet base.
	1,458,432 cubic yards.	2,108,100 cubic yards.	2,761,896 cubic yards.
Cost of excavation, at 25 cents per cubic yard	$364, 608 00	$527, 025 00	$690, 474 00
Pile-revetment from X to Y, 6,280 feet; piles 40 feet long; cost of material and driving, $3 each.	18, 840 00	18, 840 00	18, 840 00
Total	383, 448 00	545, 865 00	709, 314 00
Add 5 per cent. for superintendence and contingencies	19, 172 40	27, 293 25	35, 465 70
Total estimated cost from A to D	402, 620 40	573, 158 25	744, 779 70

ROUTE FROM A TO I.

Excavation in cubic yards for given base.—Slope 2 to 1.

	12 feet deep.		
	100 feet base.	150 feet base.	200 feet base.
	1,227,523 cubic yards.	1,835,960 cubic yards.	2,441,376 cubic yards.
Cost at 25 cents per yard	$306, 888 00	$458, 990 00	$610, 344 00
Pile-revetment as before	18, 840 00	18, 840 00	18, 840 00
Total	325, 728 00	477, 830 00	629, 184 00
Add 5 per cent	16, 286 40	23, 891 50	31, 469 20
Total from A to I	342, 014 40	501, 721 50	660, 653 20

ROUTE FROM F TO G.

This estimate includes the widening and deepening of the cut already made by Morgan (excepting that portion through Morgan's Point known as Morgan's Canal) to fulfill the requirements as given in the previous estimates, a continuation of that cut to Red-Fish Reef, and widening and deepening the cut through Red-Fish Reef to fulfill the requirements of the estimates:

Excavation in cubic yards for given base.—Slope 2 to 1.

	12 feet deep.		
	100 feet base.	150 feet base.	200 feet base.
	613,314 cubic yards.	1,137,186 cubic yards.	1,656,686 cubic yards.
Cost at 25 cents per cubic yard	$153, 328 50	$284, 292 00	$414, 171 00
Add 5 per cent	7, 666 42	14, 214 60	20, 708 55
Total	160, 994 92	$298, 506 60	434, 879 55

No estimate has been made in the above for any part through Morgan's Point, known as Morgan's Canal, included between F and V.

It will be noticed that the lowest estimated cost for any cut is that of the comple-

tion of the cut already commenced by Charles Morgan, and continuation of the same through the cut made by the General Government through Red Fish Reef; but as Mr. Morgan has spent large sums individually making the canal through Morgan's Point and extending the same for some 5 miles into the bay, under the charter, secured by him, of the old Buffalo Bayou and Ship-Channel Company, he claims and enforces his rights to charge tolls for all boats using that canal. Boats drawing over 5 feet are obliged to use his channel. For boats drawing less than 5 feet he charges 10 cents per ton, registered tonnage. For boats exceeding that draught his charges are much greater in proportion. I do not know and could not ascertain what such charges are, but the following, taken from the Galveston News of February 16, 1877, is undoubtedly authentic, and will convey some idea of these tariffs:

"TOLL FOR PASSING THROUGH THE SHIP-CHANNEL.

"The following bill has been handed to the News for publication to show the expense of taking a schooner through Morgan's Channel, a distance of half a mile. As will be seen, the channel-fees are $105.26; the towage is probably, from Galveston to Houston, $100.

"GALVESTON, *October* 23, 1876.

"*Schooner George Sealy and owners to Buffalo Bayou Ship-Channel Company, Dr.*

For channel-fees, inward	$75 25
For channel-fees, outward	30 01
	105 26
Towage	100 00
	205 26

"Paid.

"J. J. ATKINSON.
"By E. SAMIFED."

Current-observations above Morgan's Canal, in the San Jacinto River and in the canal, show that but a small percentage of water is drawn by the canal from the river proper.

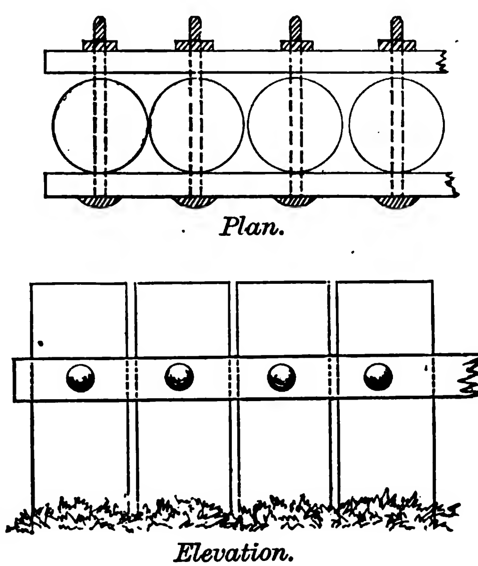
The breakwater at the head of the canal, on the west side, projects somewhat into and partially across the channel of the river, causing the water flowing into the canal to form an eddy a short distance inside the breakwater, in consequence of which a 9-foot shoal has formed. Doubtless this can only be removed and its formation prevented by dredging.

This shoal will probably form here at every high water in the San Jacinto River. Aside from this shoal, it is my opinion that Morgan's Cut, already made, has probably changed but little since dredging has been stopped. I do not think there will be any trouble in keeping any of the proposed cuts open if they have been once thoroughly made.

* * * * * * * *

The routes proposed east of Morgan's Point continue as nearly as possible the natural curve of the channel out of the San Jacinto River from A to B.

To guide the flow of water and avoid the probability of a cross-current and the consequent probable results which would necessitate frequent if not constant dredging, it is proposed to build a *pile revetment* or *retaining-wall.* The best piles to use here would be cypress, but I have estimated for pine piles, of 35 to 40 feet length, the tops driven to about 4 feet of the water-surface, and then bolted together, as shown by the following plan and elevation.


Plan. *Elevation.*

Pine piles, 1 foot diameter and 35 to 40 feet length, can be delivered at the works at from 6 cents to 7 cents per running foot length of pile. Cypress piles would cost from 10 cents to 12 cents per foot. Driving and bolting the piles, and

all necessary extra material, can be procured for less than $1 for each pile. I have therefore, estimated the cost of this retaining-wall at $3 each pile of 1 foot diameter.

It is not expected that any appreciable scouring effect will be obtained by building this wall, but, unless this water is retained by some means, the same causes that first formed Clopper's Bar will act to constantly fill up the dredged channel. It would be best to build this retaining-wall before dredging, and to throw the mud from the dredged channel behind and against it. The course of this retaining-wall has been taken with a shorter radius than that of the excavation, to secure, if possible, a direction of current at B corresponding to the straight line of excavation.

An estimate of 25 cents per cubic yard has been made upon all excavation. This includes the removal of the dumps to half a mile from the cut.

If, however, it is decided to complete Morgan's Cut, it will not be necessary to carry the mud away so far. In this case a Newton's hydraulic dredge might be used, and the cost of excavation greatly reduced.

If it is allowed to deposit the mud on the west side of the cut, at 100 or 200 feet from it, this dredge would probably be the best that could be used there. If, however, it is required that the mud be carried by dump-scows to a distance, as would be necessary if either of the other routes were selected, there would be but little advantage in using Newton's dredge. I have been induced to mention this, because one of Newton's dredges is now excavating for the Galveston Wharf Company, depositing the earth behind a retaining-wall, for 12½ cents per cubic yard, while the above estimates are for 25 cents per cubic yard.

One item not mentioned in the above estimates should be considered, viz: driving piles along the located route, about 400 feet apart.

These will be necessary partly to locate the route and assist in necessary surveys for estimates, and partly to assist the dredge-boats during the work. The cost of cypress piles, 30 feet long, would be from $3 to $3.60 each. These can be driven for 80 cents each, making the cost of each pile, for material and driving, a maximum of $4.40 each. The cost, then, on these various routes is estimated as follows:

From A to D, 181 piles, at $4.40 each	$796 40
From A to H, 162 piles, at $4.40 each	712 80
From G to H, 91 piles, at $4.40 each	400 40

Respectfully submitted,

J. A. HAYWARD,
Assistant Engineer.

Lieut. CHAS. E. L. B. DAVIS,
Corps of Engineers, U. S. A.

During June the survey in the lower bay was completed, and the assistant in charge submitted the following report, transmitted by Lieut. C. E. L. B. Davis, Corps of Engineers, who, being stationed in Galveston, was placed in general superintendence of the conduct of the survey.

REPORT OF MR. H. C. RIPLEY, ASSISTANT ENGINEER.

GALVESTON, TEX., *June* 6, 1877.

SIR: I have the honor to submit the following report of that portion of the survey for a ship-channel through Galveston Bay, Texas, placed in my charge.

On the 15th of January last verbal instructions were received from you to commence the survey at the lower end of Galveston Bay and prosecute the work in the direction of Red-Fish Bar until met by Mr. James A. Hayward, who had already commenced work at the San Jacinto River, and was prosecuting it in the opposite direction. Mr. Hayward was before this time in charge of the whole survey; but the urgency for its completion made it necessary to divide the work and place a second party in the field.

THE SURVEY.

The object of the survey was to determine the choice of two routes which should give a 12-foot channel at mean low tide extending from Red-Fish Bar; one ending in Bolivar Channel, the other to pass to the west of Half-Moon Light and Pelican Island and ending in Galveston Channel. In order to decide upon the choice of routes it was necessary not only to determine the cost of making a cut of the required depth and width and its probable permanence over each, but to ascertain the effect such a cut would have on Galveston Channel. In accordance with these requirements, a careful trigonometric and hydrographic survey of these two routes has been made of that portion of the bay which lies between Half-Moon and Red-Fish light-houses.

This has been plotted to a scale of $\frac{1}{10000}$, and is shown on Chart No. 3. That portion between Half-Moon light-house and the Gulf had already been carefully surveyed in the summer of 1876, and it was thought unnecessary to resurvey it.

Therefore a tracing of the chart of that survey has been made which connects with

Chart No. 3 and makes a complete chart of the routes proposed from the outer bar at Galveston to Red-Fish Bar. An index-chart has also been made, which embraces the entire route from San Jacinto River to the Gulf. This chart is plotted to a scale of $\frac{1}{40000}$, and is designed to show at one glance the different routes estimated upon, and also to exhibit the result of current observations and other phenomena of importance.

This chart is plotted by rectangular co-ordinates, the squares being numbered to correspond with those of the original charts.

Tide-gauges were kept at Brick Wharf, Galveston, Bolivar Point, Half-Moon light-house, and Red-Fish light-house.

The readings of these gauges have been plotted on three charts, each embracing a nodical period; the first commencing with the first descending node in January.

Where the daily record of any gauge was not complete an attempt has been made to reproduce it and thus make the curve continuous by comparison with other curves which were complete.

The dotted portion of the curve indicates the reproduction of the wanting record. The full black lines show the actual readings of the gauges. Quite a difference exists in the tides at the points observed, as will be seen by the following comparison:

Table of mean tides.

Location.	Rise and fall.
	Feet.
Bolivar Point	1.10
Galveston	1.10
Half-Moon	0.85
Red-Fish	0.48
Morgan's Point	0.38

By means of these gauges the soundings have been reduced, being referred to the plane of mean low tide at Galveston. This plane is below mean low tide for points up the bay on account of the small variation of the tides remote from the Gulf. This amounts to $\frac{13}{100}$ of a foot at Half-Moon, $\frac{31}{100}$ of a foot at Red-Fish, and $\frac{36}{100}$ of a foot at Morgan's Point.

A series of current-observations were taken at four points in the bay, and the results have been tabulated, together with simultaneous gauge-readings, wherever gauges were kept, and the direction and velocity of the wind at Galveston as obtained from the United States signal observer at that place. The positions of the current-observations are shown on the index-chart, marked Nos. 1, 2, 3, and 4. A compass-dial is put on the chart at each position, by which one is enabled to see readily the directions of the currents as given in the tables.

ESTIMATES.

The following table of estimates shows the amount of excavation necessary to make a 12-foot channel at mean low tide, and its cost at 25 cents per cubic yard, over each of four cuts. The center line of each cut is shown on the chart by a red line. The cut K–L extends in a straight line from the lower end of Red-Fish Cut to Bolivar Channel. The cut D–E extends from what is known as Middle Pass, Red-Fish Bar in a straight line to Bolivar Channel.

The cut K–R extends in the arc of a circle from K to M, straight from M to N, in the arc of a circle from N to O, straight from O to P, in the arc of a circle from P to R, where it ends in Galveston Channel.

The cut D–R extends in a straight line from D to S, in the arc of a circle from S to T, in a straight line from T to N, where it unites and coincides with the cut K–R to R.

The estimates are for widths of 100 feet, 150 feet, and 200 feet, with slope of two on one.

Table of estimates for a 12-foot channel.

	100 feet wide.		150 feet wide.		200 feet wide.	
	Cub. yards.	Cost.	Cub. yards.	Cost.	Cub. yards.	Cost.
From K to L	587,427	$146,856 75	864,384	$216,096 00	1,141,326	$285,331 50
From D to E	619,483	154,870 75	909,958	227,489 50	1,201,089	300,272 25
From K to R	1,063,244	265,811 00	1,558,510	389,627 50	2,053,435	513,358 75
From D to R	1,085,931	271,482 75	1,591,701	397,925 25	2,097,136	524,284 00

CURRENTS.

By inspecting the tabular exhibit of current observations, I think a very correct idea of the currents, of the lower portion of the bay at least, may be obtained. Inspecting the currents at each position separately, it is to be observed that at station No. 1, at one stage of the tide, the current flows directly toward West Bay. From this it gradually veers to the W. (diminishing its velocity) and N. W. ½ N., attaining its greatest velocity at N. W. ¼ W. At other stages of the tide the direction of the current varies between E. ½ N. and S., attaining its greatest velocity E. S. E. It will be observed that only one observation shows any current having a direction north of W. ½ N. and E. ½ N., and this is so small that I think it is due to the wind or is an error of observation or recording. At station No. 2, at one stage of the tide the current flows toward West Bay, attaining its greatest velocity S. W. ½ W.

From this it veers to the west, diminishing its velocity until it reaches W. ½ N., when the current almost entirely disappears.

At other stages of the tide the current varies from N. by W. ½ W. to S. E. by E., attaining its greatest velocity E.

But these last mentioned were so gentle compared with the force of the wind at the time of observation, that they were greatly if not entirely influenced thereby. At station No. 3 the observations were continued for a period of 17 days, and during that time great uniformity was observed in the directions of the currents. After flood-tide was established, they varied between N. N. W. and N. E. by N. ¾ N. A few observations gave directions exceeding these limits, but were due to the effects of wind. After the establishment of ebb-tide, the currents varied between S. E. by S. ½ S. and S. S. W. The greatest observed current not influenced by winds, flowed S. S. E. ½ S.

But quite a number of the observations show a strong current, bearing west of south, and this was especially the case when the wind had an easterly direction. Currents in other directions were observed which occurred during the changes of the tide, but none of sufficient force to be of any importance.

At station No. 4 stronger currents were observed than at either of the other stations. The greatest currents flowed in a south-southeasterly direction.

The ebb-tide currents varied in direction from S. E. ½ S. to a little west of south, and with a small velocity to nearly southwest.

In changing to flood it veered to the west, and during flood-tide varied in direction from N. ½ W. to N. W. by N., attaining its greatest velocity at about N. W. by N. Only on one day was there any current observed having a direction between the limits north and east, and this was obviously due to a strong southwest wind.

From the foregoing we are able to arrive at the following facts with regard to tidal currents when not influenced by strong winds. The bay being full and ebb-tide established, the water flows east in Bolivar Channel, north in Galveston Channel, where it unites with Bolivar Channel, deflecting the latter slightly to the north, and preventing it from scouring away the shoal which lies east from Fort Point. The water in West Bay flows in a northeast by east direction, meeting the water flowing south from the bay above, near Virginia Point, is deflected to the east, leaving a wedge of slack-water extending east from Virginia Point. The water in East Bay flows in a west-southwesterly direction until it meets the water from the upper bay, when it is deflected toward Bolivar Channel. But its momentum is sufficient to bank the water up on the west side of the bay, between Dollar and Shoal Points, and thus increasing the quantity of water flowing west of Pelican Island. The more remote from the Gulf the later will be the establishment of the ebb-currents, so that when the flood-tide sets in through Bolivar Channel the ebb-currents in the remote parts of the bays may be at a maximum.

The phenomena of flood-tide seem to be as follows:

The tidal wave in the Gulf arrives in front of Bolivar Channel when the ebb-current is nearly at a maximum. The water begins to rise rapidly, banking up on the outer bar, giving the deepest water on the bar when the water is lowest inside.

The flood-tide soon forces its way west in Bolivar Channel, checking and reversing the currents that it meets directly, but only checking and deflecting those met at an angle.

The flow continues up the bay reversing the current fram the upper bay. The current from East Bay meets the flow up the bay at right angles, forcing it slightly to the west, which, together with the current west of Half-Moon flowing south, tends to fill up the southwestern portion of the bay, and thus prolong the ebb-current through Galveston Channel. This sometimes amounts to two hours or more, and at a time of double tides, when the flood-tide is of short duration, the ebb-current will not cease in Galveston Channel while it will flow and ebb again in Bolivar Channel.

The current in Galveston Channel thus impinging against the prism of water in Bolivar Channel, finds its only mode of escape to the east, and we have two currents side by side flowing in opposite directions, with a wall of slack-water or prism of eddies between them.

But if the flood-tide continues, the current in Galveston Channel is reversed, and,

after passing the city, flows west and uniting with the water which flows from Bolivar Channel around the west end of Pelican Island, they together flow into West Bay.

After flood-tide is established in both Galveston and Bolivar Channels the water divides where the two channels fork, leaving a wedge of sluggish water extending east from Pelican Spit. Bolivar Channel divides and subdivides into smaller and still smaller channels, between each two of which there exists a wedge of more or less sluggish water and corresponding shoals.

The most southerly of these channels lies nearly east and west along the north side of Pelican Island, and its water flowing westerly divides, part flowing southwest and part northwest, leaving a wedge of slack-water extending from the shore south of Shoal Point.

The tendency of such a wedge of slack-water is to form a shoal of the same form, but instead we find one nearly circular.

This variation is obviously due to other currents, for as soon as West Bay is filled, or nearly so, this southwest current ceases and the current from Galveston Channel flows (at station No. 1) in a northwesterly direction, impinging against the shore south of Shoal Point, keeping a channel open along the shore.

The point of this wedge-shaped formation is washed away by the ebb-tide, and hence its circular form, as shown on the chart.

The current observations were not extensive enough to determine the phenomena of the currents up the bay or to explain the formation of the shoals at Half-Moon, Shoal Point, Dollar Point, and Hannah's Island.

It is important to remark that the observations go to prove that West Bay is filled generally by water flowing both through Galveston Channel and Bolivar Channel, (passing around the west end of Pelican Island); that it is sometimes filled entirely by water from Bolivar Channel passing around the west end of Pelican Island; that it is always emptied through Galveston Channel; that Galveston Channel discharges more water into the Gulf than it receives from it; that the ebb-current continues in Galveston Channel some time after the tide has commenced to flow in Bolivar Channel, and that this is due to the influence of East Bay by which the water is forced into the cove west of Pelican Island. It seems a subject of legitimate speculation whether a dam from Pelican Island to the main land south of Shoal Point would not prevent the formation of the inner bar.

In seeking an explanation for the phenomena of tides as observed, estimates have been made of the areas of the several bays and of the mean relative amount of water each receives and discharges during the flowing and ebbing of a single tide. For convenience of discussion, I have divided the basin into sections, as follows:

All that portion above Red-Fish Reef will be called Upper Bay; all east of a line extending north from Buffalo Point to Smith's Point will be called East Bay; all that portion lying north of a line joining Buffalo Point and the northwest end of Pelican Island, and thence west to the mainland, not included in Upper and East Bays, will be called North Middle Bay; that portion lying south of a line from the northwest end of Pelican Island west to the mainland, and a line joining Pelican Spit and Fort-Point breakwater, not included in West Bay, will be called South Middle Bay; and that portion of West Bay extending to Cronkaway Reefs will be called West Bay.

The following table shows the area in square miles and discharge from each section. I have assumed for the tide in Upper Bay a mean of the mean tides at Red-Fish and Morgan's Point; for the tide in East Bay and North Middle Bay a mean of the mean tides at Bolivar Point and Red Fish; for the tide in South Middle Bay the mean tide at Half-Moon; and for the tide in West Bay a trifle more than the mean tide at Red-Fish.

Areas and capacities of sections between the planes of mean high and mean low tides.

Section.	Area.	Tide.	Capacity.	Relative capacity.
	Sq. miles.		*Cu. rods.*	
West Bay	29.5	.50	91,539	....
South Middle Bay	22	.85	116,053	....
West and South Middle Bays	51.5	......	207,592	100
East Bay	78.8	.80	391,230	188
North Middle Bay	89.7	.80	445,350	215
Upper Bay	231	.43	616,450	297
Whole basin	451		1,660,622	800

In the above table it will be seen that the capacity of East Bay is about ⅔ as great as that of Upper Bay, while its area is only about ⅓ as great. West Bay and South Middle Bay are combined in the table, for we have considered them as the natural basin to be filled and emptied through Galveston Channel. But our observations show

that this area is too small to represent the amount of discharge, but that it is sometimes, and probably often, too large to represent the amount of influx.

North Middle Bay we regard as a reservoir to be filled and emptied with each flow and ebb of the tide through Galveston and Bolivar Channels, having no tendency to select one in preference to the other except on account of the greater slope due to the shorter distance via the latter to and from the Gulf. The same is true of the Upper Bay, except that on account of its greater distance the momentum the water acquires while ebbing may favor its discharge through Boliver Channel. But East Bay evidently exerts an influence on Galveston Channel on account of the momentum its water acquires while ebbing, which tends to force the water down into South Middle Bay and thus prolong the ebb and shorten the flood tide in that channel.

The circular motion produced by the waters of East and West Bays flowing in opposite directions was undoubtedly the cause of the formation of Pelican Island and spit and the shoal which surrounds them. From an inspection, therefore, of the conformation of the bays, together with the tidal curves at different points, one would be led to expect tidal phenomena not greatly different from those actually observed.

CONCLUSIONS.

Fears have been entertained by many that a cut from Red Fish Bar to Bolivar Channel would diminish the flow through Galveston Channel, and thus endanger its permanence or diminish its capacity; but from a consideration of all the phenomena we are forced to the conclusion that such fears were not well founded, and that, instead of being injurious to Galveston Channel, the tendency of such a cut would be just the reverse, for it would tend to prevent the prolongation of the ebb-current in that channel, which is injurious in three particulars, viz, first, by the formation of the inner bar; second, the filling of the channel on account of an obstructed outlet; and, third, the delaying of the flood-current until the bays are partially filled, and thus losing the effect of the flood-tide at a time when the greatest difference in the level of the Gulf and bays exists. However, we do not anticipate that so small a cut would have a very marked influence, and if the products of dredging be removed it would probably not be appreciable.

Of the four cuts proposed K-L is, for several reasons, the most desirable. It will afford a straight channel from deep water in the Government cut at Red Fish Bar to deep water in Bolivar Channel. It can be made at less expense than either of the others, and it gives great assurance of permanence. The dredging should be deposited on the west side of the cut, both as a source of economy and in the hope of deflecting the current from East Bay towards Bolivar Channel. If the end would warrant the expense, I think a row of close piling on the west side of the cut, with the dredging deposited back of it, would assist in the improvement of Galveston Channel beyond all reasonable doubt.

The only advantage of the line D-E is in being in the prolongation of a straight line from the mouth of the San Jacinto River to Red Fish Bar.

The objections to the line K-R are that the cost of cut would be nearly twice as great as on the line K-L; that it would give a crooked instead of a straight channel, and that it would not afford so much certainty of permanence. The same objections in a greater degree militate against the line D-R.

I have been assisted, both in the field and office work, by Mr. R. B. Talfor, assistant engineer; also by Mr. J. C. Buchanan, assistant engineer, who took the current-observations.

Very respectfully, your obedient servant,

H. C. RIPLEY,
Assistant Engineer.

Lieut. C. E. L. B. DAVIS,
Corps of Engineers, U. S. A.

The charts named in the report of Assistant Hayward were transmitted with my preliminary report. Those named in the report of Assistant Ripley are transmitted herewith.

The reports, together with their accompanying charts, I think furnish sufficient data for estimate and for decision as to location of a line on which to excavate the proposed channel through Galveston Bay.

ITEMS OF EXPENDITURE.

Boats, fixtures, &c	$128 10
Hire of schooner, &c	700 00
Instruments	560 00
Material	407 55
Rent	50 00

Stationery	$72 40
Service	6,033 33
Provisions	488 09
Telegrams	13 97
Transportation	136 20

Money statement.

Amount appropriated by act approved August 14, 1876	$10,000 00
July 1, 1877, amount expended during fiscal year	8,589 64
July 1, 1877, amount available	1,410 36

REPORT OF BOARD OF ENGINEERS.

ARMY BUILDING, NEW YORK,
September 10, 1877.

GENERAL: The Board of Engineers appointed by Special Order No. 9, dated Headquarters Corps of Engineers, Washington, D. C., January 25, 1874, and reconvened by Special Order No. 95, dated Headquarters Corps of Engineers, Washington, D. C., August 14, 1877, for the purpose of considering the question of location of a proposed ship-channel through Lower Galveston Bay, and its bearing upon the projected improvement in Galveston Harbor, has the honor of reporting as follows:

The Board met on the 11th instant, as specified in the order, and from day to day studied the data presented, arriving at the following conclusions covering the two points submitted for their consideration:

A line from Red Fish Bar to the head of Bolivar Channel would, in the opinion of the Board, be a more advantageous location for the proposed channel than the line from Red Fish Bar, passing west of Half Moon Shoal, and terminating at the inner end of Galveston Channel. The first named would be shorter, with fewer necessary curves (if any) in its course, would require a much smaller amount of dredging in its first construction, and could afterward be maintained at less cost.

The Board are aware of the advantages to navigation by giving a course to the channel straight from its commencement, at the head of Bolivar Channel, to its termination at Red Fish Bar. An uncertainty, however, which could be removed by a few observations, now exists, whether the channel might not be better maintained by giving it a slight departure from a perfectly straight course. Furthermore, it is the opinion of the Board that the harbor of Galveston, as well as the works projected for its improvement, will not be injuriously affected by the ship-channel proposed from the head of Bolivar Channel to Red Fish Bar.

A proposed location west of Half Moon Shoal, aside from consideration of much greater cost, would interfere with the original project for harbor improvement, inasmuch as it would cross the line along which it was proposed to close in the harbor, leaving open only its entrance from Bolivar Channel and through West Bay. This closure has not yet been decided upon, but may be considered desirable at some time in the future. Further, if the channel be made on this line it will be a roundabout route for vessels bound direct from the Gulf to Buffalo Bayou and the San Jacinto River, while, at the same time, it would possess no special advantages to vessels leaving Galveston for these rivers over the line proposed from the head of Bolivar Channel. It is also the opinion of the board that the portion of such channel from the head of Galveston Harbor to a point opposite the west end of Pelican Island

would be more difficult of maintenance than any portion of the other channel.

Respectfully submitted.

Z. B. TOWER,
Colonel of Engineers, Brt. Maj. Gen.
H. G. WRIGHT,
Lieut. Col. Engineers, Bvt. Maj. Gen.
JOHN NEWTON,
Lieut. Col. Engineers, Bvt. Maj. Gen.
C. W. HOWELL,
Captain of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A.

J 5.

IMPROVING SABINE PASS, TEXAS.

During the year but 10,450 cubic yards were excavated by the contractors, and no work was performed by them after November, 1876. They have evidently abandoned their contract, the Chief of Engineers was so informed, and annulment of contract recommended, for which authority was granted, and the contractors so informed by letter from this office of June 20, 1877, inviting from them a proposition for final settlement. To this letter no reply has been received.

By act of Congress approved August 14, 1876, $38,000 was appropriated "for the improvement at Sabine Pass, and for improvement of Blue Buck Bar and Sabine Bay, and for deepening the channel over the bar at the mouth of the Sabine River, and for deepening of the channel over the bar at the mouth of the Neches River, where these rivers enter Sabine Bay."

In my project of operations, dated May 18, 1877, for the expenditure of the appropriation, it was shown that if this small amount was applied to the four works contemplated by the act named, no appreciable benefit would accrue to either, and, as Sabine Pass was undoubtedly the most important of the four, it was recommended that the appropriation be applied to the former, in excavating a channel through the bar at its mouth 12 feet in depth at mean low tide, with a width of 100 feet at bottom. This recommendation was approved by the Hon. Secretary of War, and under date of June 12, 1877, I was authorized by the Chief of Engineers to so apply the appropriation, together with the balance of appropriation ($20,000) approved March 3, 1875.

Proposals for the work by contract were invited July 16, 1877, by advertisement, the bids for which will be opened August 20, 1877.

Should there be a balance sufficient, after completing the channel through the bar, it is proposed to straighten the channel through the body of the pass.

The survey required as a preliminary to the work of dredging has been ordered, and is now in progress.

Original estimated cost	$87,513 90
Whole amount appropriated	58,000 00
Whole amount expended	6,225 58

The work is located in the collection-district of Galveston, near the light-house the entrance to Sabine Pass.

In my report to the Chief of Engineers, dated February 4, 1875, I submitted revised estimates for this work, as follows:

For a 12-foot channel	$105,026 00
For a 15-foot channel	176,071 00
For a 20-foot channel	390,317 00

Money statement.

July 1, 1876, amount available	$16,658 84	
Amount appropriated by act approved August 14, 1876	38,000 00	
		$54,658 84
July 1, 1877, amount expended during fiscal year	2,884 42	
July 1, 1877, outstanding liabilities	1,285 00	
		4,169 42
July 1, 1877, amount available		50,489 42

Amount (estimated) required for completion of existing project for 12-foot channel	$47,026 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	47,026 00

J 6.

IMPROVEMENT OF PASS CAVALLO, INLET TO MATAGORDA BAY, TEXAS.

Report on the survey for this work, with project for improvement, will be found in Part I, pages 760 to 765, inclusive, report of the Chief of Engineers for the year ending June 30, 1874.

The sum of $20,000 was appropriated for the fiscal year ending June 30, 1877, for commencement of the work. Examination of the project, with its estimates, must show how entirely inadequate for commencement the amount of appropriation should be considered.

Appropriation was withheld, by direction of the Hon. Secretary of War, until late in the year.

Under date of April 25, 1877, the Chief of Engineers informed me of release, and directed submission of a project for its expenditure. The following was submitted:

NEW ORLEANS, LA., *May* 21, 1877.

GENERAL: In obedience to instructions communicated in Engineer Department letter of April 25, 1877, I have the honor to submit, with explanatory remarks, a project for expenditure of the appropriation now available "for the improvement of Pass Cavallo Inlet to Matagorda Bay, Texas." The amount, being but $20,000, is not adequate for commencement of the work, if we employ the character of construction originally proposed, viz, a gabionade.

To begin a work of this character a suitable plan must first be provided, and a large amount of material, both manufactured and for continuance of manufacture, must be collected. I am satisfied, from experience with the Galveston work, that at least $100,000 should be available before the engineer in charge should feel justified in making a commencement.

In my original project for this work, which I see no reason to change as regards general plan, that part to be first undertaken was the closure of the Elizabeth and Decrow Channels, lying between Matagorda Peninsula and Pelican Island, by a gabionade along the line XY, (see chart,) which is nearly 7,000 feet in length, the object being to cause the building out of the peninsula as far as the island, and the confinement of the waters entering and discharging from the bay to the main channel. In this respect the plan of the work is similar to that at the mouth of the Cape Fear River.

For making this closure the gabionade has many advantages, the principal of which are the rapidity with which a single tier of gabions and mats could be laid the whole length of this line to prevent excessive scour, and the possibility of afterward gradually completing the closure, so as to give ample time for the sand to form about the

structure and for the main channel to gradually accommodate itself to the new service required of it.

The only other method of closure suggested is that of a strong sheet-piling. I have made an estimate of the material required for this, and find that it will cost about $18,000, delivered.

It would be unsafe to estimate the cost of construction in so exposed a locality as this is known to be at less than the cost of material, which would make the estimate for the work $36,000. From this it appears that the appropriation may be made to complete about half the line by this method.

Since the sheet-piling would effect a total closure as it progressed, the work would be embarrassed and its cost increased by continued and increasing scour about its end. I therefore think that it would be unwise to attempt it.

The only project that I feel at all justified in recommending is one looking to an adequate appropriation at the next session of Congress for constructing the gabionade—one of preparation for the placing of gabions, viz, the placing of the guide-piling along the line XY. Even this has its objections:

1. The piling, in order to offer reasonable hope of withstanding the fall and winter storms, would be very much more costly than that required for the placing of gabions and mats, when carried on simultaneously.

2. Judging from observed effects of bridge-piling between New Orleans and Mobile, the piles would offer sufficient obstruction to the tidal currents to cause scour between them.

Those most interested in this proposed improvement urge a commencement of some kind. They argue that if the present appropriation is expended, it will better their chances for obtaining further appropriation, and of finally securing adequate appropriation for completing the work. They are possibly right. With a desire to aid them in any way that offers a show of reason, the last-stated project is submitted for consideration.

Very respectfully, your obedient servant,

C. W. HOWELL,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

After consideration of the above, the Hon. Secretary of War decided as shown in the following copy of letter from the Chief of Engineers:

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., July 19, 1877.

SIR: Your letter of May 21, last, in reference to the expenditure of the appropriation of $20,000, made by the river and harbor act of August 14, 1876, "for the improvement of Pass Cavallo Inlet to Matagorda Bay, Texas," was duly received, and submitted to the Secretary of War, June 28, with recommendation that, "in order not to risk the danger of great loss to which an unfinished or imperfect structure would be subjected, * * the expenditure of the appropriation be suspended to wait the future action of Congress." The Secretary of War has approved the recommendation of the Chief of Engineers, and you will be governed accordingly.

In the mean time you will please submit an estimate in detail of the additional sum required to proceed with the improvement without imminent risk of serious loss.

By command of Brig. Gen. Humphreys.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Major of Engineers.

Capt. C. W. HOWELL,
Corps of Engineers.

In consequence, the work has not been commenced. It cannot be undertaken to advantage under an appropriation less than $150,000.

Preparation for commencement of the work, viz: The collection, by purchase or construction, of a suitable plant, the lease of ground for manufacture and construction of quarters, store-houses, shops, and wharves, and the collection of material in desirable quantity will of itself cost between $70,000 and $80,000. To be conducted to the best advantage during the present year, the preparations for it should all be made before the 1st of February, 1878, so that construction can be commenced about the 1st of May and the favorable season for such work fully utilized.

The recommendations and estimates presented in my report of February 4, 1874, are adhered to, and further appropriation for this year of $130,000 recommended, which will make the total available $150,000.

The importance of the work has been shown in previous reports.

No commercial statistics for the past year have been received.

The work is located in the collection-district of Indianola, Texas, and the nearest light-house is that at the entrance to the pass.

Money Statement.

Amount appropriated by act approved August 14, 1876	$20,000 00
July 1, 1877, amount available	20,000 00
Amount (estimated) required for completion of existing project	695,325 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	150,000 00

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., June 28, 1877.

SIR: I submit herewith a communication from Captain Howell, Corps of Engineers, in reference to the expenditure of the appropriation of $20,000 of August 14, 1876, for the improvement of Pass Cavallo, entrance to Matagorda Bay, Texas, from which it will be seen that this sum is insufficient for the complete construction of any portion of the plan which it has been deemed advisable to adopt in an endeavor to improve this entrance.

In order not to risk the danger of great loss to which an unfinished or imperfect structure would be subjected, I beg leave to suggest that the expenditure of this appropriation be suspended to await the future action of Congress.

Captain Howell will be directed to submit an estimate in detail of the additional sum required to proceed with the improvement without imminent risk of serious loss.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brig. Gen. and Chief of Engineers.

HON. GEO. W. MCCRARY,
Secretary of War.

[Indorsement.]

The recommendation of the Chief of Engineers is approved.

By order of the Secretary of War.

H. T. CROSBY,
Chief Clerk.

July 17, 1877.

APPENDIX K.

ANNUAL REPORT OF CAPTAIN JAMES F. GREGORY, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1877.

UNITED STATES ENGINEER OFFICE,
HEADQUARTERS DEPARTMENT OF TEXAS,
San Antonio, Texas, July 10, 1877.

GENERAL: I have the honor to transmit herewith my annual report upon the work for the protection of the river-banks at Fort Brown, Texas, for the fiscal year ending June 30, 1877.

Very respectfully, your obedient servant,

JAMES F. GREGORY,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

PROTECTION OF THE RIVER-BANKS AT FORT BROWN, TEXAS, FROM ENCROACHMENTS OF THE RIO GRANDE.

The authority under which the work was done was given by the following order:

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., December 30, 1876.

SIR: The act making appropriations for sundry civil expenses of the Government for fiscal year ending June 30, 1877, contains the following item, viz:

"For work necessary for the protection of the river-banks at Fort Brown, Texas, against the encroachments of the Rio Grande, $10,000, or so much thereof as may be necessary, to be expended under the direction of the Secretary of War."

By indorsement of the War Department of December 21, on communication of the Paymaster-General, the Secretary of War approves of the assignment of this work to you, and directs that the appropriation be disbursed under the Engineer Department.

* * * * * * *

By command of Brigadier-General Humphreys.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Major of Engineers.

Capt. JAMES F. GREGORY,
Corps of Engineers.

There has been so much written by various officers of the Army who, from time to time, since 1867, have reported concerning the great and frequent changes which are continually taking place in the channel of the Rio Grande, the friable nature of the banks of the stream, and of the encroachments of the river upon its banks in front of the city of Brownsville, and the post of Fort Brown, that there is necessary here but a brief *résumé* of the condition of affairs when I assumed charge of the work of protection in January, 1877.

The evils apprehended for Fort Brown from river encroachments, besides the loss of land, were twofold, viz:

First. That in the concave bend below the site of old Fort Brown, the narrow strip of land which now separates the river from the lagoon would be worn away and the lagoon either be drained or again become the channel of the river, in the former case leaving an unhealthy marsh to the sanitary detriment of the garrison, or in the latter event probably destroying the national cemetery, which is located on an island in the lagoon. I may here report what has been so often reported upon, viz: The lagoon is filled with water at each overflow of its banks by the river. As its bed is about 5 feet above the plane of low-water surface of the river it could easily be drained at low-water, but could not be kept dry by leveeing against the river, as it is the receptacle of a large extent of surface drainage. The apprehensions, therefore, that in the event of being drained it would become an "unhealthy marsh" seem to be justified.

Second. That, judging from the rapid encroachments during the past three years near the northwest corner of the post, the river would soon break through into the northern end of the lagoon, destroying in its course some of the most valuable buildings at the post, and leaving the major portion of the reservation on the Mexican side of the river, if not in Mexican territory. The store-houses, workshops, &c., of the Quartermaster's Department, situated between the lagoon and the river, have also been considered in danger from every succeeding high-water.

Many schemes for protection along the fronts mentioned have been devised, and some of them were carried into effect. In the concave bend near the southeastern corner of the reservation a costly work of timber and sheet-piling was built some years since by the Quartermaster's Department, of which scarcely a trace now remains.

About 330 yards up stream from the garrison-wall, a pile jetty was built by private parties in 1871. Though the greater portion of this work has been washed away, a portion about 100 feet long remains. This work has been the cause of an immense accumulation of land both above and below it, which, diverting the channel at this point to the westward, has caused the rapid erosion along the northwestern front of the reservation.

The portions of the Fort Brown front which it has been considered desirable to protect are from the northwestern corner of the reservation down stream about 1,000 feet, and along the concave bend below old Fort Brown about twice that distance.

By comparing the plat of a survey made by myself with a tracing of Lieutenant Haupt's map, made in March, 1869, I found that the erosion along the front below the point of intersection of the line of officers' quarters with the river-bank had been inconsiderable in eight years, and that the dangers to be apprehended were not measurably greater than they were at the time of Lieutenant Haupt's examination. From the garrison-wall at the northwest corner of the reservation down stream to the point of intersection above mentioned the case was very different. The erosion in the intervening eight years had been at the wall about 50 feet; in front of the Administration building about 50 feet, and at a point about midway between these two about 90 feet; the erosion having almost all taken place since the erection of the up-stream jetty in 1871, and being much greater in the last two than in the four preceding years.

It was very desirable, therefore, that something be done at once to arrest the progress of erosion, and it was also considered imperative

that whatever work should be undertaken should be completed before the season of high-water, which usually comes about June 1, should arrive.

The amount appropriated did not permit the erection of any very extended work, and time was also an element of great importance. After a thorough examination of the locality, and a careful consideration of the circumstances, I recommended to the Chief of Engineers that a pile jetty or breakwater should be erected, with its up-stream end at or near the foot of Fourteenth street, Brownsville, above the point where the direct current strikes the shore with any considerable force. The axis of the breakwater to make an angle of not more than 9° with the general direction of the shore-line from the starting-point to a point on the bank in front of the Administration building; the structure to be 150 feet long, with a wing at the down-stream end connecting with the shore below, which should make an obtuse angle with the main structure, the purpose of the main structure being to deflect the current from the bank, and that of the wing to prevent erosion behind the work by the eddy which would form below it.

To prevent washing around the piles, heavy brush mattresses were to be placed under the entire structure. As the banks are eroded from below and tumble in when the pressure against them is removed by the subsidence of high water, it was believed that if the deep channel could be kept at its present distance from the bank that the erosions by the flood-water would be of small importance compared to the additional power of resistance gained by the breakwater by allowing the shortest possible leverage to the current against the piles. It was, therefore, recommended that the tops of the piles be left only high enough above low-water surface to admit of substantial double longitudinal and transverse bracing, the flood-water above about 5 feet being permitted to pass over the entire structure. This plan was approved by the Chief of Engineers, and I was directed to purchase the materials and machinery estimated for in the plan recommended, and to proceed at once with the work. The timber and materials were purchased in open market in Mobile, Ala., and the work was done by hired labor.

Pile-driving was begun on the —— of April and the work completed on the 15th of June. The piles, which are of 12 by 12 inch pine, were driven with a 1300-pound hammer having a maximum drop of 40 feet. They were driven to the extreme limit of endurance, and, with the exception of the anchorage piles, are from 18 to 29 feet in the ground. They are in two rows, 12 feet apart from center to center, and 7 feet apart from center to center in each row. They are braced by a double set of longitudinal and transverse braces of 10 by 10 timbers bolted with 1-inch screw-bolts with double washers.

Under the entire structure and projecting 6 feet outside of it are mattresses of brush composed of two cross-layers of fascines which are 1 foot in diameter and 12 and 25 feet long. The structure when completed was filled with layers of fascines of the same dimensions as those used in constructing mattresses, and of bricks and broken bricks, the only material to be obtained for ballast along the Lower Rio Grande. Upon the top stringers planks were spiked at intervals of 4 feet to keep in place the fascines and brick of the filling until sufficient sediment shall be deposited by the river to accomplish the same purpose.

Since the completion of the work there have been two rises of the river, neither of which, however, reached a height of more than 6 feet above low water.

No further recommendations with reference to the work can be made

until the effects of the next considerable rise upon it, and upon the banks just above and below it shall be seen. Such rise usually occurs about the 1st of June and again in September.

This year, though it may arrive in July, it is probable that the floods have been passed off in successive discharges from the various mountain tributaries of the Rio Grande, instead of being poured down, as is usual, at about the same time.

The following is a statement of funds showing the amounts expended during the fiscal year ending June 30, 1877, and the amount available July 1, 1877:

Money statement.

Amount appropriated by act approved July 31, 1876, making appropriations for sundry civil expenses of the Government for the fiscal year ending June 30, 1877, &c..	$10,000 00
July 1, 1877, amount expended during fiscal year	7,197 59
July 1, 1877, amount available	2,802 41

APPENDIX L.

ANNUAL REPORT OF CAPTAIN W. H. H. BENYAURD, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1877.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., July 2, 1877.

GENERAL: I have the honor to submit herewith my annual reports upon the works under my charge, for the fiscal year ending June 30, 1877.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

L 1.

IMPROVEMENT OF THE OUACHITA RIVER, LOUISIANA AND ARKANSAS.

After the close of operations for the fiscal year 1876, the snag-boat O. G. Wagner was taken to New Orleans, docked and thoroughly repaired for the work of the following season.

The appropriation of $12,000 made by act of Congress approved August 14, 1876, was, however, not made available, (except an allotment of $800 for the purpose of taking care of the property, &c., pertaining to the work,) until May 1, 1877.

Preparation was then immediately made to put the boat in commission. After repairs, incidental to being laid up so long in that climate, had been made, the Wagner was sent to the Upper Ouachita.

The project as approved being to build low-water dams across the side channel at Spoon Camp Shoals and Buffalo Flats, for the purpose of concentrating all the water at a low stage of the river into one channel; for if the steamers navigating the river could get over the obstructions at these places, they could reach Camden, Ark., and in addition the Wagner was to work during the remainder of the season in removing snags, logs, and other obstructions to the navigation of the river.

The work has only been carried on since the middle of last month, and has progressed very favorably and satisfactorily, as can be seen by the following report of Mr. Justin Straszer, in local charge:

BUFFALO FLATS, OUACHITA RIVER,
June 30, 1877.

MAJOR: I have the honor to present herewith my report on the operations of the United States snag-boat O. G. Wagner for the fiscal year ending June 30, 1877.

The snag-boat was out of commission and laid up at New Orleans, La., from July 1,

1876, to May 20, 1877, on which day I received your verbal orders to commence the necessary repairs and get the boat ready for service in Ouachita and Yazoo Rivers.

This being completed by June 8, and having taken on board the necessary supplies and outfit, I started, in accordance with your written instructions, from New Orleans, June 9, and arrived at Camden, Ark., the present head of navigation on Ouachita River, June 16.

While on the way, heavy rains throughout the country had caused an extraordinary rise in the river, which, however, commenced declining upon my arrival at Camden, Ark.

The project of improvements in Ouachita River embraces, as the most important parts, the construction of low-water dams at Spoon Camp Shoals and Buffalo Flats, distant from Camden respectively 18 and 21.75 miles, and it was decided to start in and complete this work to the exclusion of all other.

I left Camden June 18 with an additional force of twenty laborers and proceeded to Spoon Camp Shoals.

The river being still too high for any other work, the whole force of the boat was employed in cutting brush, poles, and timber, dragging them to the shore, whence it was loaded on the boat and carried to the place of construction. At the same time the construction of mattresses was commenced.

On Friday, June 22, the river having fallen to 9 feet above low water, I was enabled to make the necessary soundings and to select definitely the location of the dams, namely, to build one dam from the main left shore, across the old low-water channel to the tow-head, thence another dam to the main island, closing up a smaller chute.

The same evening I commenced the construction of dam No. 1, by towing two large mattresses, each 55 by 30 feet, into the chute, and located them with ropes in the required position. The filling with brush and ballasting with heavy oak timber, cut on the bank, was continued, to a thickness of 5 feet.

A load of rocks, 40 cubic yards, was towed from Treadway's Landing to Spoon Camp, and used for ballast and riprap.

Dam No. 2 across the small chute, from the tow-head to the island, having a length of 90 feet, was commenced on June 28, and the construction of the same carried on as before.

Heavy rains during the week caused a new rise in the river of 16 feet, which interrupted work for a few days. I started, therefore, to Treadway's Landing on June 29, loaded with 66 cubic yards of rock, and returned the next day to Spoon Camp.

The dams were found intact and solid, and will require 3 days more for completion, which will be executed as soon as the level of the river falls to the crest of the dams.

Nine snags, principally heavy water-logged timber, being in the channel at Cold Bite Shoals and in the bend above, and being serious obstructions in low-water, were removed, sawed in suitable lengths, and used as ballast on the dams.

* * * * * * *

Very respectfully, your obedient servant,

JUSTIN STRASZER,
Comdg. U. S. Snag-boat O. G. Wagner.

Major W. H. H. BENYAURD,
Capt. Corps of Engineers, U. S. A.

During the coming season it is proposed to continue the construction of the dams at Buffalo Flats and to remove the steamer Ora, lately sunk, and other obstructions to the safe navigation of the river.

COMMERCIAL STATISTICS.

The amount of commerce carried on during the fiscal year ending June 30, 1877, in Ouachita River, Arkansas, embraces—

Cotton, about 40,000 bales, valued at	$2,000,000
Oak staves, valued at	100,000
Hides and sundries, valued at	50,000
Value of down-freight	2,150,000
Value of up-freight, consisting of provisions, supplies, agricultural implements, and general merchandise, about	1,500,000
Total	3,650,000

From Ouachita River, in Louisiana, I have not been able to obtain full commercial statistics. The amount of cotton, however, shipped from

the entire river amounts to about 150,000 bales annually, estimated at $7,500,000.

The river was navigated during the season, from January 10 to June 30, 1877, through to Camden, Ark., by the following boats:

New Orleans and Ouachita River Transportation Company's Steamers:

	Tons.	Trips.
John Howard	800	8
Shanon	650	6
Era No. 9	200	3
Willie	200	6
Bastrop	350	6

Independent steamers:

Cotton Valley	500	10
Fanchon	450	3
City of Augusta	350	1

The Ouachita is in the collection-district of Arkansas, there being but one, and in the third collection-district of Louisiana.

The port of entry properly is New Orleans, La.

The amount of revenue collected at that place is $1,601,646.32.

The original estimate of operating upon the Ouachita with snag-boat is as follows:

Cost of steamer	$30,000
Running expenses, per month	2,200

No detailed estimates will be presented for the improvement of the Ouachita with the snag-boat, since the nature of the work must be continuous from year to year, owing to the character of the obstructions which each flood brings down.

The estimates are therefore only based upon the amount required to run the snag-boat for a season's work.

Amount appropriated March 3, 1871	$51,000 00
Amount appropriated June 10, 1872	100,000 00
Amount appropriated March 3, 1873	60,000 00
Amount appropriated August 14, 1876	12,000 00
Total amount appropriated	223,000 00
Total amount expended	216,169 44
Balance on hand July 1, 1877	6,830 56

The first appropriations were made with a view to the improvement of the river by means of a system of locks and dams, the estimated cost of which was $1,163,083.75, and by operating with a non-propelling crane-boat.

There had been expended under this project for materials, surveys, &c., about $160,000 when it was abandoned.

The remainder of the appropriations has been expended in the purchase of an iron-hull snag-boat and in operating it upon the river.

Money statement.

July 1, 1876, amount available	$358 03
Amount appropriated by act approved August 14, 1876	12,000 00
	12,358 03
July 1, 1877, amount expended during fiscal year	5,527 47
July 1, 1877, amount available	6,830 56
Amount that can be profitably expended in fiscal year ending June 30, 1879.	20,000 00

L 2.

IMPROVEMENT OF THE YAZOO RIVER, MISSISSIPPI.

No work was carried on upon this river during the fiscal year ending June 30, 1877, as the amount appropriated by act of Congress approved August 14, 1876, was not made available in time.

As this amount is entirely too small to provide an ample outfit and at the same time carry on the work necessary to be done, I shall be required to wait, as I have done in previous seasons, until the snag-boat Wagner can be spared from her district of operations, and put her upon the Yazoo.

Accordingly, it is proposed to continue operations on the Yazoo in the removal of the most dangerous obstructions to the safe navigation of the stream.

These obstructions consist of wrecks of steamers sunk during the war, and of snags, sunken logs, and overhanging trees.

The original estimate for the improvement of the river was $120,000, which, if extended over a period of four years, would be sufficient for many years to come.

Other streams, like the Big Sunflower, Tallahatchie, &c., navigated by the same steamers that ply in the Yazoo, and whose products are estimated in the general commercial statistics of the Yazoo River, should be included in the improvement.

In case they be so included, detailed estimates for their improvement can be submitted.

The amounts appropriated for the Yazoo have been as follows:

By act approved March 3, 1873	$40,000
(This amount was applied to the removal of the wrecks of the steamers Arcadia, R. J. Lackland, Golden Age, Glyde, Petrel, Ivy, Van Dorn, Polk, and Idaho, sunk in the stream during the operations of the war.)	
By act approved March 3, 1875	12,000
By act approved August 14, 1876	15,000

Of the latter amount there is still available $13,956.51.

The nearest port of entry is Vicksburg, and is in the collection-district of Mississippi.

The commercial statistics have not yet been obtained.

Money statement.

Amount appropriated by act approved August 14, 1876	$15,000 00
July 1, 1877, amount expended during fiscal year	1,043 49
July 1, 1877, amount available	13,956 51
Amount (estimated) required for completion of existing project	93,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	50,000 00

L 3.

REMOVAL OF RAFT IN RED RIVER AND CLOSING TONE'S BAYOU, LOUISIANA.

In previous years, the two items under the above head have been separate, and appropriations made for each.

By the act of Congress, approved August 14, 1876, they were continued in one, and the amount of $35,000 appropriated for the whole work. Of this amount I allowed $9,000 for work on the raft, and $26,000 for the work of closing the bayou.

REMOVAL OF RAFT IN RED RIVER, LOUISIANA.

In the early part of July, 1876, the river above Shreveport commenced to rise and continued rising very rapidly until the latter part of the month.

This rise loosened and brought out a great deal of long and heavy timber from above, which formed into jams below.

The appropriation for river and harbor improvements not having passed as yet, and there being no money left from former appropriations for this improvement, no work could be done by the Government boats, although several of the river steamboats which had been caught above the jams did what they could to keep the river clear.

By the 11th July navigation was entirely suspended between Shreveport and the head of the raft, the river having jammed at rafts 11, 13, and 39, with heavy drift still running from above.

The upper jam commenced forming about the 7th July, and was the heaviest that had formed since the raft was opened, its length being from 1¼ to 2 miles.

At this time the river was very high and was still rising, so that every day the length of the jam was increased, and would have become very formidable had not portions of it broken loose and drifted down the river, forming a number of smaller jams below.

About the 1st August the river began to fall, and fell as rapidly as it had risen, so that by the 25th of the month there was only 10 feet of water in the river above Shreveport; and as some of the stumps in the jam required from 7 to 8 feet of water to float the roots clear, it was feared, if longer delayed, no good effectual work could be done on account of low-water.

The river and harbor appropriation bill was approved on the 14th August, 1876, and on the 28th August authority was received by telegraph from the Chief of Engineers to work upon the removal of the jams.

The United States steamer Thomas B. Florence, with one crane-boat, was immediately sent into the raft region, and from August 28 to September 30, 1876, the following was accomplished, Capt. J. S. Tennyson being in charge of the work.

September, 1876.—During the month to the 23d the Florence was engaged in breaking up and removing jams between Shreveport and Gilmer; 12 jams were broken up and removed, the total length of which was 4,380 yards. The most serious jams were at Gold Point, 400 yards long; Lake Point, (raft No. 9,) 300 yards long; and at Egypt Plantation, (rafts Nos. 16, 17, and 18,) 1,200 yards long. These jams were formed in very high-water, and the river falling very rapidly afterwards caused great difficulty in their removal.

The crane-boat No. 1, Mr. E. H. Slocomb in charge, was supplied with a steam-saw, which was used to cut the long timber into 20 feet lengths as the Florence pulled it from the jams.

During the months of October, November, and December, 1876, and January, 1877, the Florence was employed on the Tone's Bayou work, supplying the parties carrying materials and towing barges and flats loaded with brush and poles.

In February, 1877, the *Florence* was engaged to the 17th breaking up and removing jams in the raft region; 10 jams were removed, the total length of which was 1,932 yards. As the river at this time was rising, these jams were easily broken. Seven shore-drift piles were also removed, and 74 long trees sawed by hand.

In April, 1877, the *Florence* was called out to break and remove some

heavy jams, and operated from the 18th to the 21st, inclusive. Five jams were removed, the total length of which was about 1,150 yards, and 24 long trees sawed up by hand.

RECAPITULATION.

Date.	Number of jams removed.	Total length of jams in yards.	Number of shore-drifts removed.	Number of cuts made with water-saw.	Number of cuts made with steam-saw.
1876, September 1 to 23	12	4,380	4	59	1,250
1877, February 1 to 17	10	1,932	7	74	....
1877, April 18 to 21	5	1,150	......	24	....
Total	27	7,462	11	157	1,250

In June the steamer Florence, in going from Shreveport to Cypress Bayou to assist in raising the dredge-boat, sunk in Benton Cut-off, about five miles from Jefferson. She, however, lies near the shore, in a very favorable position for raising, and as soon as a low stage of water is reached, she can be raised with but little difficulty.

The original detailed estimate for the removal of the raft (see my report of last year, also previous reports of Captain Howell) was $259,014, with additional items for keeping open the channel for first year, $50,000, and for subsequent years it was estimated that from $10,000 to $25,000 would be required.

The amount expended upon the raft-work and river in its vicinity is $306,393.06.

A portion of this has been expended in the purchase of a new boat and plant required to take the place of that wornout in service.

In my report of last year a table was presented, giving the present condition of the raft, width of channel, &c., together with estimate for the removal of the remainder of the obstructions. These additional estimates are rendered necessary from the constant and progressive formation of the raft.

While the old raft proper is being operated upon, work must also be continued to prevent the formation of new rafts, and the boats in service have been working continuously to this effect.

By reference to the above report of operations for the past season, it will be seen that new raft and rack heaps formed and were packed as tightly and were equal in extent to any one of the old raft-formations.

It must be considered that the work as now commenced must be kept up each year. One season's stoppage of work would be sufficient to effect an entire blockade of the river and prevent its navigation above Shreveport, and add considerable additional expense to effect a re-opening.

After each flood the main river and its tributaries add their quota of trees, logs, &c., to the stream, eventually becoming serious obstructions to the navigation.

Some act simply as snags, others are carried along and finally caught by some projecting bank or other obstruction, and as other additions are made, rapidly grow to the proportions of a large raft, completely blocking up the river.

To prevent as much heavy timber as possible from falling into the river and forming snags, rafts, &c., I have caused the trees on both banks, to a point within 20 miles of Fulton, Ark., to be girdled, with a

view to having them felled and cut up, so that when the flood reaches them they will float off and cannot tend to form any obstruction. If this work be continued up the main river and its tributaries, the effect will be, in a few years, to have an open river throughout the entire season, instead of being, as it is now, blocked up with every rise.

The amounts appropriated heretofore are as follows:

By act approved June 10, 1872	$150,000 00
By act approved March 3, 1873	80,000 00
By act approved June 23, 1874	50,000 00
By act approved March 3, 1875	20,000 00
By act approved August 14, 1876, for removing raft and closing Tone's Bayou	35,000 00

2. CLOSING TONE'S BAYOU, LOUISIANA.

The object of this work was to retain in the main part of Red River all that volume of water which was lost to it by the outlet through Tone's Bayou, and thus to improve the low-water navigation of Red River below.

For years past Tone's Bayou has been gradually enlarging, until last year it carried off at low water about three-fourths of the volume of water that passed through Red River above, and it was only a question of time, I believe, when nearly the whole of that amount would have gone down Tone's Bayou, and thus have utterly destroyed the low-water navigation of Red River.

Having received authority to commence the work, I decided to attempt the closing of the bayou by building a mattress-dam, as all previous attempts at piling, &c., seemed to have failed.

Having no stone, we had to have recourse to bags, filled with clay to effect the sinking The first few mattresses sunk seemed to have an effect upon the volume of water in Red River, and gave us hope that the object for which the dam was built would be effected.

The dam as now built is a low-water dam, being in height about 21 feet, the crest in the middle being about 14 feet below extreme high-water mark, thus allowing the bayou to void a great volume of water during the flood-stages, while at low water all the water is retained in Red River.

Had the appropriation been made available earlier, I reasonably expect that the entire dam would have been finished with the amount appropriated; as it was, we were thrown later into the season and experienced higher water, and meeting with a slight accident we were compelled to finish the low-water dam.

The work was in charge of Mr. Joseph Burney, assistant engineer, whose report of operations will be found below.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., February 19, 1877.

MAJOR: I have the honor to submit the following report of the building of the dam on Tone's Bayou, near Shreveport, La.:

On the 25th September I received your instructions in Memphis, Tenn., to proceed to Tone's Bayou to make examinations and surveys, and to collect information bearing upon the construction of the dam until your arrival in the following week.

During that time I made a careful examination of the bayou, taking several cross-sections, the most favorable one showing the following results at low water or reading 9′5., on the water-gauge erected during the progress of the work:

From west bank, 0′, 20′, 40′, 60′, 80′, 100′, 120′, 140′, 160′, 180′, 200′.
Depth, 0′, 11′, 24′, 21′, 21′, 21′, 21′, 17′, 12′, 7′, 0′.

Giving a low-water area of 3,100 square feet.

The low-water area of Red River, below the mouth of the bayou, showed the following result:

From south bank, 0′, 20′, 40′, 60′, 80′, 100′, 120′, 140′.
Depth, 0′, 15′.5, 18′, 9′, 6′, 6′, 3′5., 0′.

Giving a low-water area of 1,160 square feet.

The average rates of currents in Red River and Tone's Bayou were about equal, being at the rate of 2 miles per hour, thus showing that the bayou was taking nearly three-fourths of the water from Red River when it was greatly wanted for navigation, and wasting it through Bayou Pierre and the lakes, while a large sand-bar was forming immediately below the mouth of the bayou in Red River, which showed every prospect of soon becoming dry, and forcing all the water at a low stage down the bayou, which was steadily widening and deepening to receive it; thus it would only be a short time before navigation in low water to Shreveport would be suspended.

I quote below an extract from the Louisiana State engineer's report on the bayou, made in 1875, and, from my own observations made during the progress of the work, I fully agree with the opinions given:

"Tone's Bayou, twenty years ago, was an insignificant stream, only drawing water from the river at moderate stages, but now it threatens to destroy the navigation of the main channel, even when it should have sufficient water for the largest class of steamers plying in the Red River trade.

"It is every year scouring deeper and wider, while the main river is being gradually diminished in width and depth. In order to avert the danger of absolute suspension of navigation from Grand Ecore to Shreveport during 6 or 7 months of the year, and these months, say, July, August, September, October, November, December, and often January, the months when it is most desirable for the planter and the merchant to have it, Tone's Bayou must be closed up."

Major Howell, in his report on the bayou, made in 1872, states: "At the time of gauging, the discharge of Tone's Bayou was nearly double that of the river below it," and, from the figures given above, it had increased in 1876 to nearly three-fourths.

While admitting the importance of immediately commencing the work, there were nearly insurmountable obstacles to be encountered in carrying out the work to a successful close during the low water of 1876.

There was no time to make the necessary surveys, examinations, and preparation for a work of so much importance, as in a short time the high-water season would begin, when the swift current and heavy drift-logs from the raft region above would, perhaps, destroy the work if found in an unfinished condition, and many attempts had been made by able engineers, under far more favorable circumstances, which had always ended in a complete failure to close the bayou.

After carefully considering the obstacles to be encountered, in the interest of navigation, and at the urgent request of steamboat-owners, you determined to immediately undertake the work, and after selecting a location for the dam you placed me in local charge of the work, with the following instructions:

To construct the dam with willow mattresses, sand-bags, and earthwork. The dam to be 200 feet wide at the base, 80 feet wide at low-water level, and 25 feet wide on the crest, 2 feet above high-water mark; and in the construction of the dam to be careful in protecting the sides, and to always have the work in such a condition that should a heavy rise occur in the river the work could be suspended without danger until the next low-water season.

On the 5th of October, 1876, the United States steamboats Florence and Aid, two crane-boats, and about 40 workmen, left Shreveport, La., and arrived in the bayou on the same day. We then erected quarters for 120 laborers. One of the crane-boats was employed in removing snags from the bayou to allow us to float the mattresses, and a quarter-boat, with a working party, was sent up the river to obtain willows and cottonwood trees.

We then commenced building the ways for the construction of mattresses, which was done as follows:

The bank of the bayou was cut back at an angle of about 30° for 70 feet, and 70 feet wide. On this were built the ways made of 11 skids 6″ by 4″ with rounded nosing on top, placed 5 feet apart, and supported on posts 6″ by 4″ let into the ground 2′ 9″, and the skids secured by three-quarter inch spikes.

The average size of mattress was 60′ by 36′ by 3′, and was constructed in the following manner:

Across the ways, 6 feet apart, were placed cottonwood trees 36 feet long and about 4″ to 5″ diameter at the butts; these were lashed to the ways to prevent them from rolling off. At right angles to the cottonwood trees were placed other cottonwood trees 6 feet apart, and at the four extreme corners was placed an ash pin 3′ 6″ long and 1½″ in diameter; at every intersection of the cottonwood trees a one-inch pin was driven through, and each joint tied with strands of old rope; over this framework was placed a layer of willow brush, over that cottonwood trees 6 feet apart in the same direction as the last, thus making the cottonwood trees 3 feet apart and forming the

willows into basket-work. Again, on top, another row of trees 6 feet apart and at right angles to the last, and upon this a layer of willow brush, and continued the same as before until four layers of brush had been completed, when on the top were placed cottonwood trees without brush, for the purpose of holding the sand-bags used in sinking.

Each corner pin was run through the entire thickness of saplings, and wherever the joints met a one-inch pin was used, and the joints secured by strands of old rope.

Each mattress contained from 200 to 220 cottonwood trees; and estimating the brush and saplings as they were bound together, each mattress would contain about 50 cords of brush and trees.

The workmen employed in constructing the mattresses were as follows:

Occupation.	Rate of pay.	Total per month.
One overseer	$50 00	$50 00
Four corner-men	40 00	160 00
Two pin-makers	30 00	60 00
One rope-strander	30 00	30 00
Twenty laborers	30 00	600 00
Twenty-eight months' rations, at	15 00	420 00
Total cost per month for mattress-gang		1,320 00

This party under very favorable circumstances could construct 2 mattresses per day, but allowing for broken time a fair average would be 40 mattresses per month; this would make cost of construction per mattress $33.

The cottonwood trees and brush were obtained about 15 miles from the bayou and towed in barges by the United States steamer Florence to the works. From a near calculation I estimate the cost of brush delivered at the ways at $1.50 per cord, which would give cost of mattress as below:

50 cords of brush, &c., at $1.50	$75 00
Construction	33 00
Old rope	3 00
Cost of mattress	111 00

When the mattress was completed a 1-inch rope was tied to it and carried to a hoisting crab on the opposite side of the bayou. All being ready the lashings on the ways were cut and a few turns on the crab would move the mattress, when it would slowly slide into the water.

The mattresses did not have much buoyancy, for the top poles were nearly even with the water. They were then floated down to the dam, and, by means of ropes stretched across the bayou at various distances apart, the mattresses were placed in position for sinking without any difficulty. We then dropped down a flat-boat loaded with about 200 sand-bags to the upper end of mattress, and, placing the sand-bags on the end, the mattress would sink and the flat-boat would slowly float over, allowing an even distribution of the sand-bags. Then on the top of the mattress, again, we would place from 10 to 15 boat-loads of earth, equal to about 150 cubic yards.

The first mattress was sunk on October 17, 1876, and a few days later you inspected the works and approved of what had been done, with the exception of a slight alteration in the construction of the mattresses.

After constructing about 10 mattresses, the willows near the work had all been used, and we were compelled to use very coarse brush, having to cut down trees and take the tops. This brush made a very inferior mattress to the willows.

The work progressed steadily without any interruption until the 18th of November, when we had brought a part of the mattress-work up to the water-level, having placed in position 39 mattresses.

The water above and below the dam did not show much variation, being 0'.5, but a slight rise coming down, in 12 days, caused a variation of 2'. Every precaution had to be taken in placing the mattresses in position in the strong current. The ropes across the bayou had to be abandoned, and we placed the mattresses in position by ropes secured to trees on each side of the bayou.

In endeavoring to place one mattress in position the current tore out the entire end to which ropes were secured, and it went over the dam and was lost, not being able to bring it back in the current.

Another mattress we lost by the ropes breaking, and a third one was lost by the heavy drift-logs piling up against it before it was fully secured with sand-bags.

During this time we suspended carrying earth on the flats to the dam, as the water readily carried it away, and we could only use sand-bags, which we increased to about 350 per mattress.

The heavy drift caused us considerable trouble by piling up against the dam, and we were compelled to remove it. This we did by means of the capstan on the steamboat Aid.

In placing a mattress in position on the dam at this time it would raise the water above in a few minutes 0'.2, and when one was carried off it would immediately reduce it the same amount.

By the mattresses we could readily change the direction of the current to either side of the bayou, but our aim was to keep it in the center and away from the sides, which it would have rapidly cut away.

You again inspected the work, when I informed you that the means at our command for sinking the mattresses were exhausted, and you instructed me to build from the sides.

We then mattressed the sides to nearly high-water, and kept building out into the center of the stream, and wheeling on sand-bags and earth from the sides, and in this way we made rapid progress, and by leaving the center open the drift readily passed through without giving any trouble.

About December 1 the water began to slowly fall and the drift to cease running.

We closed in the center and gave the whole dam a covering of sand-bags and earth, which caused the mattresses to settle about 1'.5 very evenly.

We then continued with brush, sand-bags, and earth, as before, until the 26th December, when one of the coldest and severest storms occurred that ever visited this portion of the country, and we were unable to obtain the brush, for the workmen could not handle it on account of the snow, and we had no alternative but to build the upper portion of earth or suspend operations.

It was considered that the heavy pressure from the earth-work would give solidity to the mattresses, and it was determined to build the upper portion of the dam without brush, and by the 31st of December we had the dam about 5 feet above water-level, and it presented a very solid appearance. Although we had not succeeded in stopping the leakage, several men on horseback crossed the dam for the first time that day, and the variation of the water above and below the dam was 3'.5. We kept steadily building up, while under the heavy pressure the mattresses again sunk about 1', and in places holes would break in the earth-work, but were easily filled up. In order to prevent the leakage, a heavy amount of earth-work was placed in front of the dam, and we nearly succeeded in stopping it.

Several buggies passed over, and also a heavy wagon drawn by four mules, without danger. On the 5th of January, 1877, the snow began to melt, causing another rise in the river, while the water below the dam kept steadily falling, and on Tuesday, January 9, the variation of water above and below the dam was 5'.3. This heavy pressure against the new earth-work caused several serious caves, which we succeeded in stopping. January 8 and 9 the water kept steadily rising against the bank, and I kept two watchmen on the dam at night with a fire burning at each end, and the workmen to be called out if there was any danger. On Monday night they were called out and stopped the caving; on Tuesday night we again succeeded in stopping it, but on Wednesday morning, January 10, about 2 o'clock, a serious cave occurred. We endeavored to stop it with sand-bags, but the current carried them over the dam, and by 4 o'clock it broke entirely through, when I abandoned all hope of saving the earth work, which was carried away in two days.

During that time, although the river had been on a steady rise, the water fell 2'.8, and at Shreveport, a distance of 30 miles by river, it fell 0'.5.

I immediately sent you a telegram, and on the 12th January you visited the works, and after carefully examining the break, it was found that notwithstanding a fall of water of over 5 feet had been running over them, not a single mattress had moved, and the fall over the dam remained steady at 2'.3.

You then instructed me to build out wing-dams from the sides, carrying the same at the extreme ends above high-water mark, and to strengthen the center with sand-bags and make a low-water dam.

During the time we were engaged in this part of the work the water kept steadily rising, but the work required to be done was successfully executed.

The low-water area of the bayou is 3,100 square feet, and the water-area closed by the dam (shown on cross-section) is 3,500 square feet.

There were used in the construction of the dam 3,600 cords of brush, 16,500 cottonwood saplings, 15,000 sand-bags, 15,000 cubic yards of earth. Forty-six mattresses were constructed on the way, 60' by 36' by 3'.

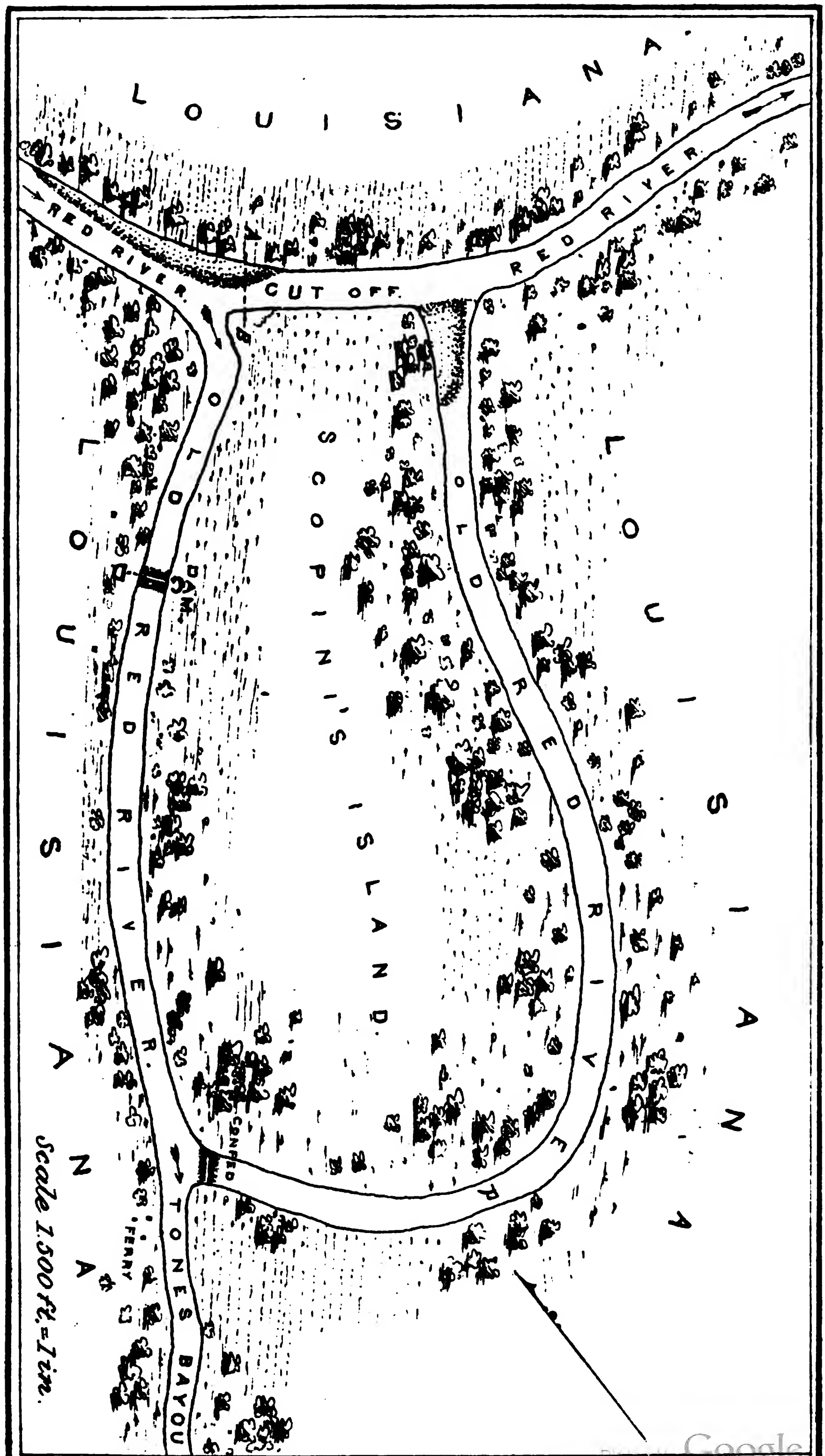
Lost during the progress of the work: 5 mattresses, 2,500 cubic yards of earth.

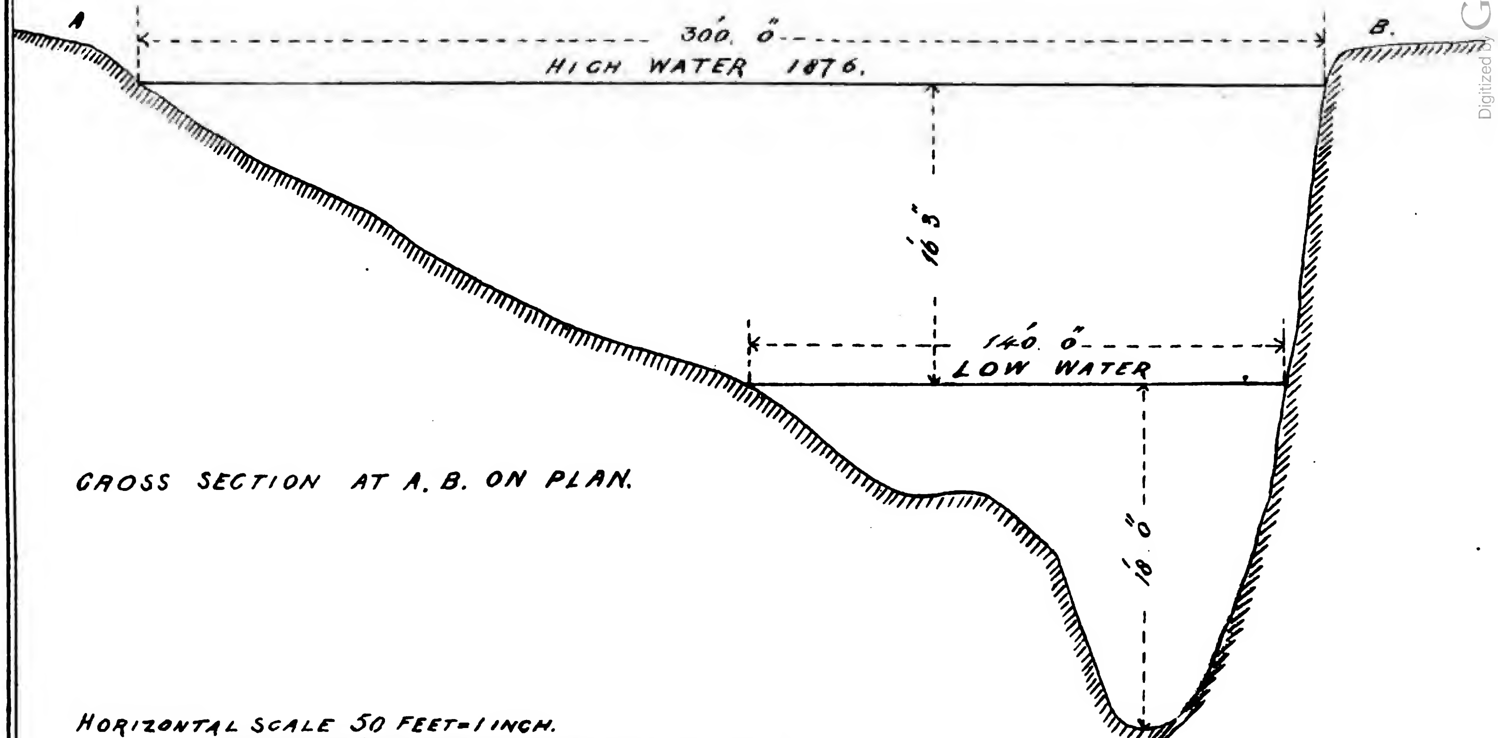
The work commenced on the bayou October 5, 1876, and ceased January 26, 1877. Time at work, 3 months and 21 days.

Accompanying this report, I submit—

One model of mattresses, constructed to a scale of ¼ inch to 1 foot.

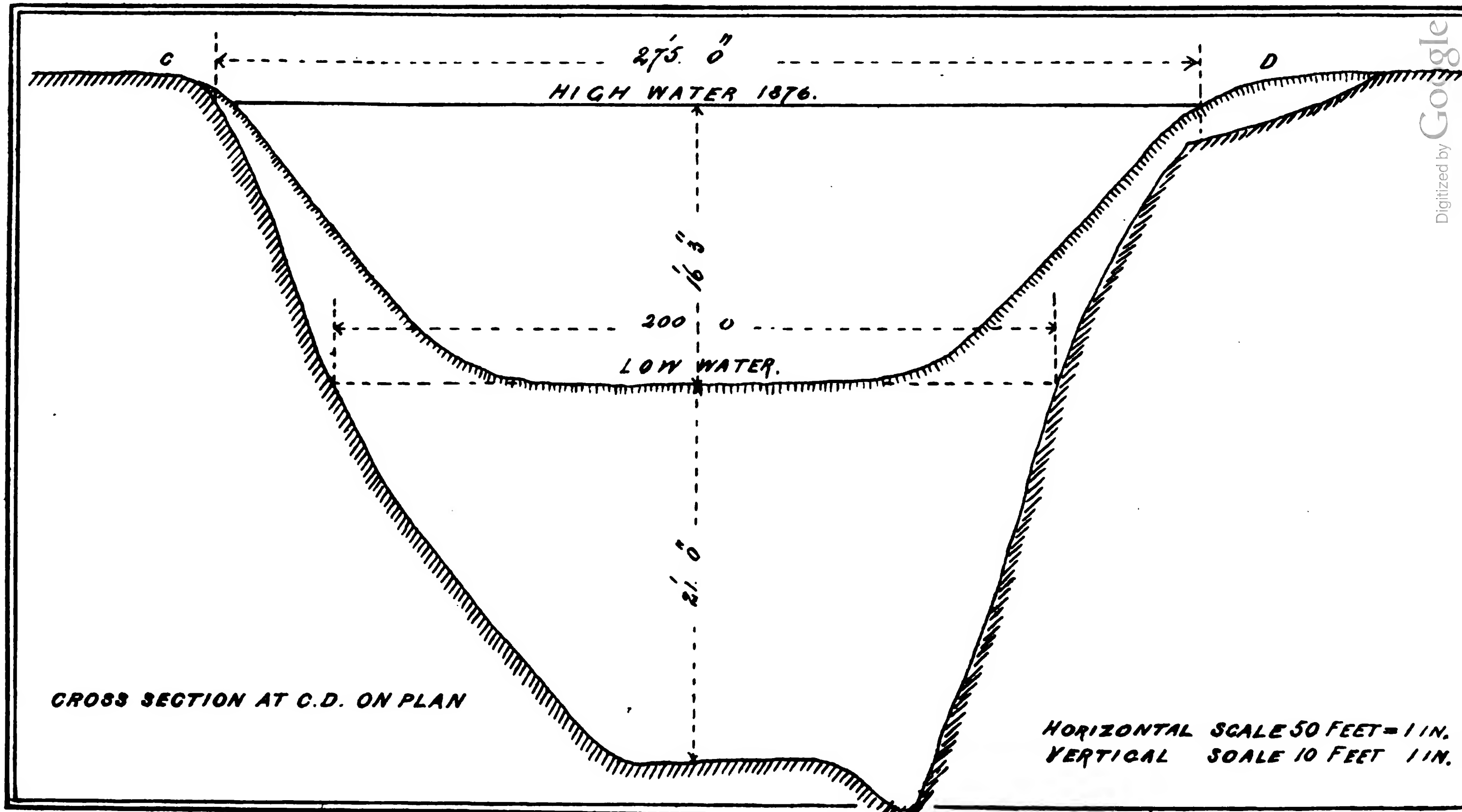
One photographic view, showing Tone's Bayou and Red River below.


LOUISIANA
RED RIVER
CUT OFF
RED RIVER
OLD RED RIVER
DAM
SCOPINI'S ISLAND
OLD RED RIVER
LOUISIANA
LOUISIANA
CONFED
FERRY
TONES BAYOU
Scale 1.500 ft.=1in.



CROSS SECTION AT A. B. ON PLAN.

HORIZONTAL SCALE 50 FEET=1 INCH.
VERTICAL SCALE 10 FEET=1 INCH.



CROSS SECTION AT C.D. ON PLAN

One photographic view, showing upper side of dam before earthwork was carried off.
One photographic view, showing lower side of dam before earthwork was carried off.
One cross-section of Red River, below mouth of Tone's Bayou.
One cross-section of Tone's Bayou at the site of dam, showing water-area closed.

I believe the cause of the bayou, from an insignificant stream, becoming one of its present size, threatening soon to destroy the navigation above in Red River, was due to the work done on the river by the State and other engineers.

About 18 years ago a cut-off was made about a mile above the mouth of Tone's bayou through stiff blue clay. This would not have increased the size of the bayou, as the water still kept the old channel, but a dam was constructed across the old channel below the mouth of the bayou, thus forcing the water either through the cut-off or down the bayou, and as the bed of the cut-off was much more tenacious than the bayou, the latter steadily year by year widened and deepened, drawing off the water from Red River; and if it had not been closed, would in a short time have destroyed over 600 miles of navigation on Red River and its tributaries for 6 months in the year.

I have every reason to believe that the present dam will be permanent, but it will have much to contend against this high-water season.

The site on which it is built is very susceptible of scouring, and the heavy drift may form a dangerous jam in front.

I would respectfully recommend that at the ensuing low-water the dam should be repaired, strengthened, and raised about 5 feet higher in the center, and I estimate that $10,000 could be advantageously expended and be of great benefit to the important navigation of Red River.

I have the honor to remain, very respectfully,

JOSEPH BURNEY.

Maj. W. H. H. BENYAURD,
Captain of Engineers, U. S. A.

The dam at the present time is still intact and has well withstood the heavy flood of this spring. Some caving has taken place on the left-hand bank, but so far no damage has occurred to the dam.

It is recommended that an appropriation be made to finish off the top of the dam, left uncompleted when the high-water came upon us last winter, and also to protect the banks below from caving, so as to prevent the water from cutting around the ends of the dam.

As Old River below cuts out from the effects of the water being retained in the channel, some addition can be made to the height of the dam each season, until finally the entire closure be effected.

The above works are situated in the third collection-district of Louisiana.

There is no light-house near them.

The nearest port of entry is New Orleans, La., of which the following statistics for the fiscal year ending June 30, 1877, are given:

Total value of imports	$9,522,559 00
Total value of exports, domestic	70,197,732 00
Total value of exports, foreign	151,584 00
	70,349,316 00
Total amount of revenue collected on imports	1,601,646 32

Statement of number and tonnage of vessels entered at and cleared from the port of New Orleans during the year ending June 30, 1877.

Entrances.			Clearances.		
Number.	Class.	Tonnage.	Number.	Class.	Tonnage.
403	Steam	466,088	395	Steam	467,570
730	Sail	462,564	748	Sail	396,517
1,133		928,652	1,143		864,087

The following are the commercial statistics of Red River at Shreveport.

During the season ending June 30, 1876, there was received at New Orleans from Red River 168,000 bales of cotton, as follows:

From Shreveport	59,355
From Old River and above the raft	12,372
From Jefferson and the lakes	14,475
From Red River below Shreveport	81,798
	168,000

There was also received at Shreveport 22,683 head of live stock, most of which was shipped to New Orleans.

An immense amount of lumber is also brought down, principally from Little River, estimated at 2,500,000 feet annually.

To this should be added the transportation of the freight up the river, consisting of merchandise, supplies, farm-implements, &c., estimated to be one-fourth more than the value of the cotton which reaches Shreveport.

Money statement.

July 1, 1876, amount available for removing raft	$207 15	
Amount appropriated by act approved August 14, 1876	35,000 00	
		$35,207 15
July 1, 1877, amount expended during fiscal year on raft-work	6,393 06	
July 1, 1877, amount expended during fiscal year on Tone's Bayou	26,551 77	
		32,944 83
July 1, 1877, amount available		2,262 32
Amount (estimated) required for completion of existing project for raft-work		140,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879, for raft-work		50,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879, on Tone's Bayou		10,000 00

L 4.

CONTINUING THE WORK OF DREDGING AND REMOVING OBSTRUCTIONS TO NAVIGATION IN CYPRESS BAYOU, TEXAS.

Operations have heretofore been confined to the work of improving Cypress Bayou proper, by cutting out and dredging a straight channel through from Jefferson to the mouth of the bayou, and in removing stumps, logs, and other obstructions from the channel.

No work was done to that effect during the past fiscal year, the balance on hand at the commencement of that year being only $22.10.

The dredge-boat with which we have operated in the bayou was sunk last winter, and owing to the high stage of water preventing any attempt being made to raise her, she has remained in that condition. The machinery, &c., however, is in safe condition.

With the amount appropriated by act approved August 14, 1876, I have commenced the construction of a new hull, and propose to transfer the machinery, &c., from the old to the new dredge.

When this work is completed, (the estimated cost of which is about $9,000,) the balance of the appropriation will be expended in continuing the work of dredging and removing the obstructions.

I estimate that for the purpose of finishing up the dredging and straightening the channel through the bayou, the sum of $20,000 will be required.

The former appropriations are as follows:

By act approved June 10, 1872	$10,000
By act approved March 3, 1873	50,000
By act approved August 14, 1876	13,000

(For collection-district and port of entry see report on removal of raft in Red River and closing Tone's Bayou, La.)

COMMERCIAL STATISTICS.

The commercial statistics are as follows:

Nearly the whole of Eastern Texas depended upon the water navigation for its exports and imports, Jefferson, standing at the head of navigation, being the principal distributing point; but since the construction of the Texas and Pacific Railroad, which runs through the city, a large portion of the business has been diverted from New Orleans to Saint Louis.

The city of Jefferson contains about 5,000 inhabitants, and below I give statistics of business for 12 months ending August 31, 1876.

Cotton receipts, 40,333 bales; of this 25,032 were forwarded to the various markets by railroad, and 15,301 by steamboat.

Amount of sales during 12 months:

Groceries and produce	$671,872 00
Dry goods	354,000 00
Hardware	119,000 00
Groceries and dry goods mixed	767,232 40
Drugs, clothing, &c	267,000 00
Machinery, wagons, &c	247,000 00
Total	2,426,104 40

The city contains a court-house which cost over $80,000, and a market-house, over $40,000; also two banks. The First National has a paid-up capital of $200,000, and its business for 12 months was over $10,000,000.

The Citizens' Bank, with a capital of $60,000, did a business of nearly $5,000,000.

The citizens of Jefferson are now engaged in building a narrow-gauge railroad over 100 miles long, and entirely with their own capital; 35 miles have been constructed; 20 miles more is contracted for, and the balance will be finished as soon as possible. It will run through the following counties: Marion, Morris, Cass, Bowie, Titus, Camp, Hopkins, and Hunt.

The census of 1870 for these counties showed the following acreage, products, and valuation:

Cotton, bales	35,908
Improved land, acres	300,334
Unimproved land, acres	1,302,406
Value of farms	$4,583,740
Value of farm products	$4,961,837
Value of live stock	$2,652,879

There is great competition between the railroads and steamboats. When navigation is suspended, the railroads greatly increase their charges.

The price per bale for cotton delivered in Saint Louis when navigation is closed, is $4.

The price per bale, navigation open, is $3. By rail and Red River to New Orleans, navigation closed, per bale, $4.

By rail and Red River, navigation open to Jefferson, $2.50 per bale.

Cotton per bale from Jefferson to New Orleans averages from $1.50 to $2, carried by steamboat.

Further showing the benefits derived from navigation, I quote price per car-load and distance from Saint Louis to cities with and without navigation:

From Saint Louis to Texarkana, distance 480 miles, per car-load, $105. No navigation to city.

From Saint Louis to Jefferson, distance 545 miles, per car-load, $75. Navigation to city.

From Saint Louis to Marshall, distance 561 miles, per car-load, $105. No navigation to city.

From Saint Louis to Shreveport, distance 600 miles, per car-load, $75. Navigation to city.

By steamboat competition, cotton is carried to the various markets at a reduced cost of from $1 to $1.50 per bale; thus effecting a saving on 40,000 bales of $50,000, while it keeps down the rates on all other exports and imports, which, at a moderate estimate, would amount to $50,000. Thus through the benefit of navigation Eastern Texas saves annually $100,000 by cheap transportation, without considering the advantage derived by having her trade competed for by Saint Louis and New Orleans.

The citizens of Jefferson are fully aware of the benefits derived from navigation, and have appropriated and expended over $60,000 in improving Cypress Bayou.

Money statement.

July 1, 1876, amount available	$22 10
Amount appropriated by act approved August 14, 1876	13,000 00
	13,022 10
July 1, 1877, amount expended during fiscal year	3,121 37
July 1, 1877, amount available	9,900 73
Amount that can be profitably expended in fiscal year ending June 30, 1879	20,000 00

L 5.

SURVEY OF THE RIVER FRONT OF MEMPHIS, TENN.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., February 5, 1877.

GENERAL: In accordance with instructions contained in your letter of January 5, I have the honor to make the following report upon the survey of the port of Memphis, with plan and estimate for the protection of the river-front.

At the time the letter above referred to was received, a considerable quantity of ice had gathered along the river-bank directly in front of the city, and extended for some distance around the bend above Wolf River. About the same time the river commenced rising very rapidly, (reaching finally before the completion of the field-work to within about 8 feet of extreme high-water mark,) causing the ice-gorges above to break, so that the river was for a number of days filled with quantities of floating ice. This was crowded by the current directly against the bank we were most concerned in having correctly and properly surveyed,

and considerable difficulty was experienced in carrying on the hydrographical work. It was even thought at one time that the survey would have to be abandoned altogether. The difficulties encountered delayed us somewhat in the prosecution of the work, and prevented us from making so detailed and thorough a survey as could have been wished; still, sufficient reliable data were obtained upon which to form a plan and base an estimate for the protection of the wharf and landing from destruction by the current of the Mississippi River.

The survey, which was conducted by my assistants, Mr. T. W. Nicol and Mr. W. W. Carson, extended from the head of Tennessee chute to the elevator at the foot of Beale street, including the Arkansas side, and also the lines of Tennessee and Frame chutes. Fifteen sections of the bank were also made below Wolf River, extending out beyond the deepest water, showing the depths at different points, and the profiles of the caving bank. I was also furnished by the city engineer with maps showing the shore-lines of previous years, and with borings made at the foot of Exchange street. This information has been embodied in our map.

That part of the city front below Madison street has undergone very little change. Within the memory of persons now residing in the city the shore-line ran about in the direction shown on the map by the dotted line, embracing a considerable portion of what is now known as the navy-yard property, and also a portion of the angle included between the Mississippi and Wolf rivers. Changes taking place in the river above caused a bar to form, which gradually extended out, forming the bank and land upon which afterward was located the United States navy-yard and other property below. This formation was in time attacked by the current, and since 1859 has continued to cave very rapidly. It is estimated from surveys made by the city engineer that within this period upward of 22 acres of ground have been washed into the river. That portion lying between the Mississippi River and Wolf River was never occupied by permanent buildings, but below the latter stream a number of structures, including cotton-warehouses, coal-yards, an iron-mill, and other buildings have been destroyed. At the present time valuable oil-mills and other costly buildings are in danger of being undermined and ultimately destroyed. The injury done to the city and the dangers arising from the encroachments of the river upon the landing are well set forth in the memorial of the general council of Memphis to Congress, a copy of which was transmitted to the Department with my letter of December 30 last. I need not therefore repeat the same here.

The survey shows that from above Tennessee Chute the current follows the Arkansas side very closely, and cuts deeply into the bend on that side above Hopefield; thence it is deflected to the Tennessee side, where the whole bank is abraded from a point about 2,000 feet above Wolf River to about Monroe street, and as the abrasion will continue down stream the remainder of the front is also threatened. An inspection of the map will show the amount of land destroyed in the past 10 years. No work looking to the protection from this constant caving has ever been attempted by the city. A costly landing of stone extending from Jefferson street to the elevation was built, but as this was continued only down to about low-water, it afforded no protection to that portion of the bank where it was absolutely needed. The greater part of this landing has been destroyed by the caving.

For the protection of the river-front of Memphis, various suggestions have been made by persons interested in the improvement. It has been proposed to attempt to turn the Mississippi into the Loosahatchie, thus

bringing it out Wolf River; also to turn the main current down through Tennessee Chute; also the building of a dike above Wolf River, for the purpose of forcing the current to the Arkansas side. These schemes I deem utterly impracticable, and not worthy of any consideration. The remedy must be applied directly to the portion of the abraded bank. Two plans suggest themselves. First, by a series of short spur-dikes, with a bank revetment between them. Second, by a continuous revetment of the bank with brush and stone. A glance at the cross-sections on the map shows that the depth varies from 50 to 70 feet at low-water, these depths being reached at distances from the shores varying from 120 to 200 feet. The expense attendant upon the building of these dikes in water of so great a depth, increased by the settling that would also take place, and taking into consideration the fact that the bank needing protection is a landing-place for all the Mississippi steamers, and the consequent interference with navigation, I deem the plan of continuous revetment the best to be adopted.

This plan will consist in covering the caving bank from about 10 feet above low-water down to the maximum depth with a covering of brush mattresses or rafts loaded with stone. The average width of this covering will be about 175 feet, and the length of shore to be protected is about 7,600 feet.

I have divided the space to be protected into two parts, that below Wolf River, which is the most important and needing immediate attention, in length about 5,600 feet, and that part above Wolf River, in length about 2,000 feet, which, while needing protection, is not so important, as the interests at stake are not so great.

The following is presented as an estimate of the cost of the work:

BELOW WOLF RIVER.

$5,600' \times 175 \times 2\frac{1}{2} \div 128 = 19,100$ cords brush mattresses, @ \$3 per cord in position	\$57,300 00
16,000 cubic yards stone, @ \$3.50 in position	56,000 00
Temporary works, contingencies, &c	12,700 00
	126,000 00

ABOVE WOLF RIVER.

$2,000' \times 175 \times 2\frac{1}{2} \div 128 = 6,800$ cords brush mattresses, @ \$3 per cord	20,400 00
5,000 cubic yards stone, @ \$3.50	17,500 00
Temporary works, contingencies, &c	6,100 00
	44,000 00
Total for whole length of work	170,000 00

The work, if once commenced, should be continuous, and, therefore, if an appropriation be made it should be sufficient to complete either the one or the other of the above divisions.

Very respectfully, your obedient servant,

W. H. H. BENYAURD,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

Statement of receipts at the port of Memphis, Tenn., for the year ending June 30, 1877.

Duties on imports	\$33,403 96
Marine-hospital dues	2,523 60
Steamboat inspection	1,699 40
Licenses to masters, pilots, &c	3,250 00
	40,876 96

Total receipts of cotton at Memphis, season of 1875-'76, 487,376 bales, valued at \$27,070,615.

L 6.

WATER-GAUGES ON THE MISSISSIPPI RIVER AND ITS PRINCIPAL TRIBUTARIES.

Observations have been continued at all the gauges throughout the entire year, and the resulting readings have been plotted in the office.

As there was no appropriation made for the gauges by the last Congress, and being desirous of keeping up the observations, I have been unwilling to expend any portion of the balance of the former appropriation for the purpose of having the hydrographs photolithographed as in last year's report, and they are therefore omitted in this.

Observations of the Carrollton gauge for each month have been furnished Major Comstock and Captain Brown for their official use.

Repairs have been made to the gauges at Carrollton, Fort Leavenworth, Helena, and Vicksburg.

A new gauge was erected at Memphis on the site of the old one, destroyed by the caving in of the city levee.

When the water falls I shall be obliged to make certain necessary repairs to the gauges at Alexandria, Lake Providence, Red River Landing, and Helena; otherwise all the gauges are in good order.

The observers are still the same as those mentioned in my report of last year, with the exception of the one at Vicksburg. At this place Mr. H. P. Raworth was appointed to take the place of Mr. Geo. W. Bausman, jr.

I would most earnestly call attention to the fact that no appropriation was made for the gauges at the last session of Congress.

The balance of the old appropriation now on hand will be only sufficient to continue the observations until October, if no extensive repairs will be required. After that time the readings will have to be discontinued.

The object for which the gauges were established was for the purpose of having a collection of continuous records, for a series of years, of the rise of the Mississippi River, with a view to obtaining information upon the question of reclaiming the alluvial basin of the Mississippi River from overflow; also to give reliable report of the river at its various stages for the benefit of the steamboat and planting interests.

As Congress has already taken initiatory steps toward making provision for the work of reclaiming the overflowed lands, by providing for a survey of the entire river, and which is now in progress, it will be seen how important it is to have the observations at the different gauges continued.

There is transmitted herewith copies of the gauge-records for the year ending June 30, 1877.

Money statement.

July 1, 1876, amount available	$1,537 26
Amount appropriated by act approved August 14, 1876	5,000 00
	6,537 26
July 1, 1877, amount expended during fiscal year	4,869 02
July 1, 1877, amount available	1,668 24
Amount that can be profitably expended in fiscal year ending June 30, 1879.	5,000 00

APPENDIX M.

ANNUAL REPORT OF MAJOR CHARLES R. SUTER, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1877.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., July 21, 1877.

GENERAL: I have the honor to submit herewith my annual report upon the operations committed to my charge for the fiscal year ending June 30, 1877.

I am, general, very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

M 1.

REMOVING SNAGS AND WRECKS FROM THE MISSISSIPPI, MISSOURI, AND ARKANSAS RIVERS.

The sum of $50,000 was allotted to this work from the appropriation made by act approved August 14, 1876, and was expended during the past season in snagging operations on the three rivers designated, five and a half months' work being accomplished. Of this three and a half went to the Mississippi, and one month each to the Missouri and Arkansas rivers.

The principal portion of this work was done by the iron snag-boat Macomb, the wooden snag-boat De Russy being only used for six weeks on the Mississippi.

Of course, with such scant means, it was not possible to do thorough work, and the operations of the *Macomb* in the lower Mississippi and Arkansas were also much impeded by the heavy ice of last winter.

MISSISSIPPI RIVER.

Operations on this stream extended from Saint Louis, Mo., to Vicksburg, Miss.

The snag-boat De Russy, after undergoing considerable repairs, left Mound City, Ill., October 12, 1876, and worked four times over the section of the river between Cairo and Saint Louis. This boat was laid up and crew paid off on the 30th of November, 1876.

The snag-boat Macomb commenced work in the Mississippi River at Cairo, Ill., November 23, and worked twice over the river from Cairo to Vicksburg, being laid up and crew paid off February 15, 1877.

As before stated, this work could not be thoroughly done on account

of the heavy ice, which greatly impeded the movements of the boat and also covered up the snags.

Table of work done in the Mississippi River.

Name of boat.	Number of snags pulled.	Weight in tons of 2,000 pounds.	Number of trees cut.	Number of drift-piles removed.	Number of wrecks removed.	Number of miles run.
J. N. Macomb	326	6,936.7	36	4	......	1,092
R. E. De Russy	350	6,477.1	367	....	......	805
Total	676	13,413.8	403	4	......	1,897

MISSOURI RIVER.

Work in this stream extended from the mouth to Booneville, 195 miles, and was carried on by the snag-boat Macomb, which left Mound City October 12, 1876, and was assigned to the Mississippi work November 20, 1876. She passed twice over her beat, removing such snags as were most in the way.

Table of work done in the Missouri River.

Name of boat.	Number of snags pulled.	Weight in tons of 2,000 pounds.	Number of trees cut.	Number of drift-piles removed.	Number of wrecks removed.	Number of miles run.
J. N. Macomb	161	1,788.8	....	5	....	632

ARKANSAS RIVER.

Work in this stream extended from the mouth of White River to Silver Lake, the highest point reached by the snag-boat Macomb, which entered the river January 15, 1877, and returned to the Mississippi January 31. The work was much impeded by ice.

Table of work done in the Arkansas River.

Name of boat.	Number of snags pulled.	Weight in tons of 2,000 pounds.	Number of trees cut.	Number of drift-piles removed.	Number of wrecks removed.	Number of miles run.
J. N. Macomb	193	2,241.6	234	3	......	557

Recapitulation of work during the fiscal year ending June 30, 1877.

Name of river.	Number of snags pulled.	Weight in tons of 2,000 pounds.	Number of trees cut.	Number of drift-piles removed.	Number of miles run.
Mississippi River	676	13,413.8	402	4	1,897
Missouri River	161	1,788.8	......	5	652
Arkansas River	193	2,241.6	234	3	557
Total	1,030	17,444.2	637	12	3,106

OPERATIONS FOR THE COMING SEASON.

Congress at its last session having failed to pass the river and harbor bill, there remains for operations during the coming season only a small allotment of $10,000 for snagging-operations in the Missouri River. Under the present uncertainty as to the future action of Congress on this subject, it would be imprudent to expend any portion of this sum in field-operations, and, in accordance with your instructions, it will be held for the care of the boats and other property of the Government belonging to this work. This enforced cessation of work by the snag-boats will greatly imperil river-navigation, and it is to be hoped that Congress will at an early day take such action as will enable work to be prosecuted during next winter and spring at least. If this is not done, the accumulation of snags by next summer will be very great indeed, and will tax to the utmost our almost worn-out fleet.

In my last annual report I described the condition of our boats, and endeavored to show the necessity of at once providing funds for replacing some of them, in order to carry on the work with greater efficiency. To this report I beg leave to refer, as the facts therein set forth are now of even greater importance than they were a year ago. The great advantage of having iron hulls for these boats can no longer be questioned.

The snag-boat Macomb, during her work last season, twice received injuries sufficient to sink a wooden boat, but her work was not stopped, and the damages were easily repaired by the crew.

My recommendations of last year, regarding the construction of new hulls for the machinery of some of the present wooden boats and for the repair of the rest, are renewed.

The work is situated in the collection-district of New Orleans. The amount of revenue collected at the port of Saint Louis, Mo., during the fiscal year ending June 30, 1877, was $1,423,370.23.

The commerce benefitted by the work is that of the entire Mississippi Valley.

ESTIMATE OF AMOUNT REQUIRED FOR FISCAL YEAR ENDING JUNE 30, 1879.

For building one large iron-hulled snag-boat to carry machinery of one of the present wooden boats	$140,000 00
For building one small iron-hulled snag-boat to carry machinery of one of the present wooden boats	105,000 00
For building one small iron-hulled stern-wheel snag-boat	60,000 00
For repairing one wooden snag-boat and fitting it up for wrecking purposes	50,000 00
For working-expenses of five boats, 10 months each, at $4,000 per month	200,000 00
Total	555,000 00

Money statement.

uly 1, 1876, amount available	$4,358 98
Amount allotted from appropriation by act approved August 14, 1876, for improvement of the Mississippi, Missouri, and Arkansas rivers	60,000 00
	64,358 98
July 1, 1877, amount expended during fiscal year	55,184 19
July 1, 1877, amount available	9,174 79
Amntrequired for the fiscal year ending June 30, 1879	555,000 00

M 2.

REMOVING SNAGS AND WRECKS FROM WHITE AND SAINT FRANCIS RIVERS.

No appropriation has been made for the improvement of these rivers since 1873, but as work is much needed there, and will probably eventually be provided for, I submit herewith estimates for carrying it on.

A small iron stern-wheel snag-boat should be built for this service.

The former appropriations are as follows:

Allotted from appropriation for contingencies of rivers and harbors (act approved July 11, 1870) for the improvement of White River	$10,000 00
Appropriated by act approved March 3, 1871, for the improvement of Saint Francis River in Arkansas	10,000 00
Appropriated by act approved March 3, 1873, for the improvement of White and Saint Francis rivers	50,000 00

The collection-district in which the work is situated is New Orleans, and the nearest port of delivery Memphis, Tenn. The nearest fort is Fort Gibson, Indian Territory.

The amount of revenue collected at Memphis, Tenn., during the fiscal year ending June 30, 1877, was $40,876.96.

During the high-water season the commerce of these rivers is large, and regular lines of packets are maintained.

During low-water, when the nature of the obstructions will not admit of a competition with the railroads, the commerce is small, and is mostly confined to the local trade of those points not reached by the railroads.

ESTIMATE OF AMOUNT REQUIRED FOR FISCAL YEAR ENDING JUNE 30, 1879.

For building one stern-wheel iron snag-boat	$60,000 00
For operating same ten months, at $4,000 per month	40,000 00
Total	100,000 00

Money statement.

Amount that can be profitably expended in fiscal year ending June 30, 1879. $100,000 00

M 3.

IMPROVEMENT OF THE MISSOURI RIVER OPPOSITE SAINT JOSEPH, MISSOURI.

A report upon this subject was submitted to you January 25, 1876, and was published in your annual report for 1876, Appendix L 4.

An allotment of $10,000 was made for this work May 17, 1877, and

will be expended during the present season in protecting the shore near the dikes erected by the bridge company, and in strengthening work already in place.

The work is situated in the collection-district of New Orleans, and the nearest port of delivery is Omaha, Neb. The nearest fort is at Leavenworth, Kans.

Amount of revenue collected at Omaha, Neb., during fiscal year ending June 30, 1877, was $2,583.30.

ESTIMATE.

Revetment of 6,400 feet of bank:	
For 7,500 cords brush mattresses, at $3 per cord, (placed)	$22,500 00
For 64,000 cubic yards of stone, at $1.75 per cubic yard, (placed)	112,000 00
	134,500 00
Excavation, contingencies, &c	15,500 00
Total	150,000 00
Amount allotted from appropriation by act approved August 14, 1876, for improvement of the Mississippi, Missouri, and Arkansas rivers	10,000 00
July 1, 1877, amount expended during fiscal year	901 19
July 1, 1877, amount available	9,098 81
Amount (estimated) required for completion of existing project	140,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	80,000 00

M 4.

IMPROVEMENT OF THE MISSOURI RIVER AT NEBRASKA CITY, NEBRASKA.

An allotment of $15,000 for carrying on this work was made December 1, 1876. A survey of the locality was made, and a report, with plan and estimate, was submitted to you February 14, 1877.

Subsequently a modified plan was submitted for the expenditure of the sum allotted, (copy herewith,) and operations will be commenced as soon as the river has fallen sufficiently. The entire sum available will be expended during this season.

The work is situated in the collection-district of New Orleans, and the nearest port of delivery is Omaha, Neb. The nearest fort is at Leavenworth, Kans.

The amount of revenue collected at Omaha, Neb., during the fiscal year ending June 30, 1877, was $2,583.30.

ESTIMATE.

For 3,500 linear feet of dike, at $35 per foot	$122,500 00
Contingencies and superintendence	12,500 00
Total	135,000 00

Money statement.

Amount allotted from appropriation by act approved August 14, 1876, for improvement of the Mississippi, Missouri, and Arkansas rivers	$15,000 00
July 1, 1877, amount expended during fiscal year	3,229 43
July 1, 1877, amount available	11,770 57
Amount (estimated) required for completion of existing project	135,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.	75,000 00

MODIFIED PLAN OF IMPROVEMENT.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., May 22, 1877.

GENERAL: In accordance with your instructions to submit revised estimates and plans for the expenditure of the sum allotted for the improvement of the Missouri River at Nebraska City, Nebr., I have the honor to report that I have carefully considered the subject, and while still regarding the plan submitted February 14, 1877, to be correct in principle, I have concluded that the great discrepancy between the amount of money available and the sum estimated as necessary, renders it expedient to adopt entirely different means for carrying it out than those recommended. The plan submitted to you contemplated the construction of permanent dikes of brush and stone, so located as to change the direction of the current in the bend above Nebraska City, restoring it as nearly as possible to an old channel, during the occupancy of which there was no tendency to injurious cutting of the banks in the neighborhood of the town.

For the success of this plan, it seems, however, to be essential that considerable results should be accomplished while the river remains substantially at one stage, otherwise the work done is liable to be lost, and this of course requires that ample funds should be available. This not being the case, I have concluded that our only chance of success will lie in using means of a more temporary nature by which we may be enabled to accomplish considerable results in a short time, leaving it to future legislation to provide funds for more permanent constructions, should they be found necessary. In carrying out this idea, I rely greatly upon the well-known instability of regimen of the Missouri River and the great rapidity with which natural causes are known to produce great changes. It seems reasonable to suppose that judiciously selected artificial means will produce the same results, and if this reasoning is not entirely faulty, I think we may be able, at comparatively slight expense, to make important changes in the river-channel. To effect this, I propose to endeavor to induce large deposits of sand, in such places as may be deemed desirable, by gradually obstructing and slackening the current at these places and thus form bars, which will force the channel to follow the line deemed desirable. I propose to use rope nets anchored across the stream, trailing-ropes with brush attached to them, and if necessary slight brush dikes, the object in all cases being to induce deposits of sand which will deflect the current instead of imposing this duty upon the works themselves.

All these expedients have successfully been used before, especially on the rivers of India, which are very similar to the Missouri in many respects. Should these experiments prove successful, the problem of improving such streams as the Missouri, at practicable cost, will be greatly simplified, and even if unsuccessful the loss will not be great, and the experience gained will be invaluable. Should the means proposed accomplish the desired end, even for a time, the construction of more permanent works, which may be required to maintain the results obtained, will of course be much facilitated and simplified.

In a work of this character, which must be carried on from day to day, using such measures as necessity may dictate at the time, there will be too much uncertainty to allow of contract-work. The material needed must be procured when wanted, and the work must be performed by hired labor.

Should the plan recommended meet with your approval, work will be commenced as soon as funds are available.

I am, general, very respectfully, your obedient servant,

CHAS. R. SUTER,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

M 5.

IMPROVEMENT OF ARKANSAS RIVER AT FORT SMITH, ARKANSAS.

The sum of $10,000 was allotted for this work, the object being to remove a bar which obstructs the free access to the city landing. A survey of the locality is in progress, and as soon as possible a plan for carrying on the work will be submitted for your approval. The entire sum available will probably be expended this season.

This work is situated in the collection-district of New Orleans. The nearest port of delivery is Memphis, Tenn., and the nearest fort is Fort Gibson, Indian Territory. The amount of revenue collected at Memphis, Tenn., during fiscal year ending June 30, 1877, was $40,876 96.

Money statement.

Amount appropriated by act approved August 14, 1876	$10,000 00
July 1, 1877, amount expended during fiscal year	304 51
July 1, 1877, amount available	9,695 49

M 6.

IMPROVEMENT OF WHITE RIVER ABOVE JACKSONPORT, ARKANSAS.

No work was done under this appropriation last season, the sum of $10,000 appropriated by act approved August 14, 1876, for the improvement of White River at Buffalo Shoals, Arkansas, having been withheld until March 29, 1877. Our maps of this locality were too imperfect to allow of the work being commenced at once, and a survey which was authorized is now in progress. Upon its completion a plan for the expenditure of the money will be submitted to you.

The small snag-boat Thomas Trunnel, belonging to this improvement, was sunk by the ice, at Mound City, Ill., last winter and became a total loss.

The necessity for removing snags and bowlders from this portion of White River is very great, and to carry on this work, and also to enable additional surveys to be made, $60,000 will be required.

The only former appropriation made for this work was $50,000, by act approved June 23, 1874.

New Orleans is the collection-district in which the work is situated, and the nearest port of delivery is Memphis, Tenn. Fort Gibson, Indian Territory, is the nearest fort The amount of revenue collected at Memphis, Tenn., during the fiscal year ending June 30, 1877, was $40,876.96.

The commerce of the country adjacent to the river is commensurably

large to the existing facilities for transportation. Its amount cannot be even estimated, as much is transported by teams from the upper country to stations on the Saint Louis and San Francisco Railroad.

Should the improvement of the river be made, the agricultural and mineral products of the country would be very largely increased.

Money statement.

Amount appropriated by act approved August 14, 1876	$10,000 00
July 1, 1877, amount expended during fiscal year	183 33
July 1, 1877, amount available	9,816 67
Amount (estimated) required for completion of existing project	700,234 37
Amount that can be profitably expended in fiscal year ending June 30, 1879	60,000 00

M 7.

SURVEYS OF THE MISSOURI RIVER AT OMAHA AND COUNCIL BLUFFS, PLATTSMOUTH, BROWNVILLE, AND ATCHISON.

The sum of $5,000 was allotted to defray the expenses of surveys ordered at the points named above.

The survey at Omaha is well advanced, and the others will be taken in hand as rapidly as possible.

Money statement.

Amount allotted from appropriation by act approved August 14, 1876, for improvement of the Mississippi, Missouri, and Arkansas rivers	$5,000 00
July 1, 1877, amount expended during fiscal year	2,007 24
July 1, 1877, amount available	2,992 76

APPENDIX N.

ANNUAL REPORT OF COLONEL J. H. SIMPSON, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1877.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., August 1, 1877.

GENERAL: I have the honor to submit herewith my annual report for the fiscal year ending June 30, 1877.

In addition to the duties connected with the works of river and harbor improvement under my charge, I have also served as a member of the Board of Engineers constituted by Special Orders No. 52, Headquarters Corps of Engineers, dated June 22, 1876, to inquire into the expediency of causing sheer-booms to be placed above bridge-piers on the Mississippi River.

I was also detailed by Special Orders No. 99, Headquarters of the Army, Adjutant-General's Office, May 19, 1876, as president of a board to retire disabled officers, to convene at Saint Louis on the 29th of that month, which board was dissolved by Special Orders No. 108, dated June 1, 1876, without performing any duty for which it was constituted.

In forwarding my report, I cheerfully acknowledge the valuable aid of my assistants and clerks, who have never failed to perform their duty assiduously and completely, and without whose assistance the Government could not have accomplished the favorable results which I believe have attended the engineering operations of this district. These gentlemen are Capt. Charles J. Allen, Corps of Engineers; Assistant Engineer Robert E. McMath; and S. S. Hutchins, chief clerk, with S. G. Clark, his assistant, in the office; and Assistant Engineers D. M. Currie, Charles S. True, and W. S. Simpson, in the field, and William Popp, assistant engineer and draughtsman, both in field and office.

Very respectfully, your obedient servant,

J. H. SIMPSON,
Colonel of Engineers, and Brevet Brig. Gen. U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

IMPROVEMENT OF THE MISSISSIPPI RIVER BETWEEN THE MOUTHS OF THE ILLINOIS AND OHIO RIVERS.

BETWEEN THE ILLINOIS AND MISSOURI RIVERS.

The funds available for the continuation of the works in this section were:

Balance July 1, 1876	$3,682 76
Provided in act approved August 14, 1876	15,000 00
	18 682 76

It was proposed to continue the construction of the dam at Piasa Island, and to make such repairs and extensions as were needed to the abutment of the dam at Alton Slough.

DAM AT PIASA ISLAND.

Work was commenced in October under arrangements made for purchase of material in open market, riprap being delivered on barges near the dam at 70 cents a cubic yard. The material was unloaded and placed in the dam by hired labor. Work was continued until the end of November, when it was suspended for the season.

The expenditures were:

30 mooring-piles	$156 31
5,474.92 cubic yards riprap	5,097 80
Engineering and contingencies	2,271 53
	7,525 64

The foundation of the dam was completed, and the base of dam widened throughout its length. The revetments below the dam were extended to a length of 150 feet on both banks. The dam is now considered secure, though incomplete. The available balance will be applied toward the completion of the prism of the dam. It will probably be necessary to revet the head of the island, as it is being cut away to some extent. The channel has continued good in this vicinity.

ALTON DAM.

Owing to the early setting in of winter less work was done toward extending the revetments below the dam than was intended. The west abutment now extends 235 and the east 220 feet below the center line of the dam. These lengths will probably be sufficient, but the revetments are incomplete in height. When last reported the height of the dam was stated to be 10 feet above low water. The height was materially reduced by the ice this spring, by very heavy fields passing over the dam when the river broke up.

The expenditures on the dam were:

569.68 cubic yards riprap	$652 17
Engineering and contingencies	44 23
	596 40

It is proposed to complete the revetments this fall. No complaint has reached this office of any failure of the dam in practical results. Local interests frequently urge that the dam be raised so as to be a high-water dike, available for a roadway, to which proposition no engineering objections can be raised.

PROTECTION OF SAWYER BEND.

No work was done at this locality for want of means. The old revetment has been somewhat injured where the ice has cut through the rock facing. The damage is not serious, but it is hoped that means will be provided at the coming session of Congress for the continuation of this work.

LONG DIKE, NEAR VENICE.

For reasons given in my last year's report nothing has been done at this locality.

The work remains in the same condition as at the date of last report.

A survey and estimate of damages, if any, done or to be done to riparian owners, by reason of the Government improvements, has been ordered, and will be made as soon as practicable, when a report will be submitted.

CLOSING CAHOKIA CHUTE.

This work was authorized by special clause in the appropriation bill of August 14, 1876, providing $29,600 toward the construction of a low dam and the revetment of Arsenal Island. The island was being cut away by the river so rapidly that it was necessary to devote the whole appropriation to securing the remnant of the island and the site of the proposed dam. A low revetment was made of part of the west side of the island for a distance of 600 feet, in two sections of 450 and 150 feet, respectively, being separated by a projecting clay point, which, protruding beyond the line adopted for the final eastern limit of the river, was left unprotected in order that it might be cut away. On the east side of the island the immediate vicinity of the dam was protected by a revetment 750 feet in length, extending 450 feet below the line of the dam. This revetment was carried to the top of the bank. The eastern or Illinois shore was also revetted for a distance of 500 feet.

The expenditures were—

2,478.8 cubic yards riprap, west shore of Arsenal Island	$2,832 61
8,092.3 cubic yards riprap, east shore of Arsenal Island	9,268 04
5,542.7 cubic yards riprap, Illinois shore	6,192 12
Engineering and contingencies	2,665 84
Total	20,958 61

Nearly all the work on the Illinois shore, and nearly one-half of that on the east side of the Island, was done in February and April of the present year. All this work is in good condition. But little more can be done until further appropriation is made. The estimate for the dam is, as stated in last report, $75,000 for a low dam.

The projected closing of this chute compels a consideration of the consequences which will result therefrom to the harbor and commerce of Saint Louis. Heretofore the expansion of the waterway at the island into two channels, either capable of passing the whole volume of the river at ordinary stages, has relieved that portion of the harbor below the bridge from dangerous pressure when ice was running, and the west bank in the vicinity of the island has for many years been considered one of the safest winter-harbors on the river. On December 3, 1876, the ice gorged in the Cahokia Chute, compelling the whole body to pass down the Arsenal Channel. The immediate consequence was the total loss of several steamers and barges, and material injury to many others.

The losses were at first estimated at nearly $200,000; but as the river was wholly blocked in a few days, and remained firmly closed for two months, some of the sunken boats were raised, and others endangered were secured, lessening the final loss. Much apprehension was felt lest, when the ice broke up, all the remaining boats should be destroyed. Fortunately the gorge in Cahokia Chute ran out February 1, the other chute remaining closed until the 8th; consequently the hard ice of the harbor found an open passage on the opposite side of the river to the exposed property, and little damage was done. The experience of the last winter from natural causes affords an illustration of what will be the yearly experience when the chute is closed by a dam. There will then be no place within convenient distance of Saint Louis where boats can lie during the winter with reasonable safety. The tonnage employed on the upper rivers will be compelled to retire to

Alton Slough betimes, and that of the lower river, of which a considerable part cannot pass under the bridge, will have no refuge, and must remain away from Saint Louis, or incur the risk of being lost should a sudden intense cold find them there. As the inevitable result of closing the chute will be to deprive the tonnage of Saint Louis of its only ice-harbor, it seems necessary to call attention to the danger, and to suggest a remedy; for the interests of commerce demand that there should be a winter harbor of refuge in the immediate vicinity of Saint Louis. The proposed dam is a necessary improvement, and, in my opinion, can readily be so designed as to afford a much better winter-harbor than has ever existed.

If the proposed dam be made a high one, the pool below it will afford a perfectly secure and easily-accessible harbor, provided it can be kept from filling up with sand. With a high dam and the side-protection of the island there would be little danger of the pool itself filling; the only problem would be to keep a sufficient entrance to it open.

I am confident that this can be done by extending the point of the island artificially to within a short distance of either the railroad embankment and incline opposite Carondelet, or within like distance of a dike, which might be constructed near the Bessemer Iron Works, and near the proposed location of the Saint Clair and Carondelet Bridge.

Having made no special surveys for the purpose, I am not able to submit any estimate of the cost of modifying the project as suggested. The fact that a part of the working-equipment belonging to the United States shared in the danger of last winter mentioned above, and to a small extent in the damage, compelled me to share in the anxiety felt by all interested in the exposed property, and justifies this proposition to extend the projected works with a view to obviate such risks hereafter.

The sudden and unexpected formation of ice at so early a date rendered it impracticable to remove the Government property from the locality, which the results showed to be a dangerous one, though judging from former experience, no one could have selected a place less likely to be dangerous.

From comments made last winter, it would seem that comparatively few comprehend the nature of ice-risks in the Mississippi, which are much more serious than would naturally be expected, considering only the latitude and mean climate at Saint Louis.

Ice forms along the margin of the river at a temperature of about +20° F. and below. Owing to the rapid current it is continually being detached, and as the temperature falls, the quantity becomes very great. By attrition between the masses it is reduced to the form of mush-ice, which in extreme cold becomes more compact, and when the river is full, heavy masses are cemented together under pressure by "regelation." While moving, the mass is often several feet in thickness and capable of crushing vessels by pressure, when its soft condition and very slow movement scarcely suggest the thought of almost resistless power. In this state it arrives at some part of the river exceptionally narrow or shoal; in the former case the mass is compacted together on the surface and solidifies very quickly under pressure; other ice following, piles upon its surface and is drawn under until a complete dam is formed and the ice is said to be gorged. This dam arrests both ice and water until the accumulated head furnishes energy either to break through the dam, cut around it, or to lift the dam high enough to detach it from the sides; when the first or last contingency occurs the movement is rapid, and no human device can avail to save whatever is exposed. During the last winter the gorge in Arsenal Chute was found by actual measurement to be 22 feet in depth, and the water-level, at one time, 8 feet higher at the

Arsenal than at Elwood street, Carondelet, 3 miles below. With these facts in mind, it is easy to understand why such serious disasters sometimes occur; indeed the wonder is that anything escapes.

The losses from ice at Saint Louis since 1865 must aggregate over $500,000. Should the opportunity now available at Arsenal Island not be improved, and the chute be allowed to silt up, as would naturally result from a low dam, there would then be no opportunity to secure a harbor of refuge within 30 miles of the city. I therefore recommend the matter to the consideration of Congress, and those interested, as worthy a close examination.

HORSETAIL BAR.

As stated in the last annual report, the navigation at this locality was extremely bad during a great part of the season of 1876, furnishing occasion for much complaint, and criticism of the work which had been done for its improvement. The facts concerning which there could be no dispute were, that after an unusually long high-water period, attended with very active erosions in the vicinity of Arsenal Island, (Horsetail being the natural place of deposit for this eroded material,) the bed of the river was filled with sand to the height of about 10 feet above low-water mark; the dikes at that time were none of them higher than 8 feet above low-water; it is therefore plain, that with a depth of channel of only 6 feet and a stage of water above 14 feet, the dikes could have been exerting no influence either beneficial or injurious; they, therefore, did not cause the difficulty, and are only chargeable with the failure to prevent it.

The work done in the years 1873 and 1874 was chiefly designed to relieve the difficulty at the then bar opposite Jefferson Barracks. The difficulty now referred to was located nearly 2 miles farther up stream, a locality where previous to 1875 there had been no trouble since 1870. When this bar made its reappearance in 1875, works were commenced with a view to its removal; this work, begun in October, 1875, had not progressed far enough to exert any appreciable influence when suspended in December for want of funds. No additional means were provided until the latter part of September. 1876. As soon as practicable, after that date, work was resumed and vigorously pushed. Owing to the raising the dikes, and the fall of the river, a channel was scoured out which became available October 23, one month and two days after the work was begun.

This channel gradually deepened until the close of the navigation, affording from 6½ to 9 feet, which latter depth was maintained through the early spring of 1877, at stages varying from 8 to 12 feet. The dikes, therefore, acted promptly and satisfactorily, as soon as the stage of water brought the channel within their influence, and continued to do so until the water rose to a stage which prevented further observation, or inquiry concerning them.

As a result of the year's operations, dikes 1, 2, and 3 are raised to a height that will bring them into action when the river falls below an 18-foot stage, and we may, therefore, anticipate that the difficulties which were experienced in 1875 and 1876, while the river was falling from 15 to 9 feet above low-water, will not be repeated in the same locality. There is, however, a possibility that there may be trouble farther down stream, owing to the insufficient height of dike 4 and incomplete state of dike 5. With the means now on hand it is the intention to resume work with the expectation of being able to prevent serious trouble, if there should be a tendency of the mean-stage channel to run across dike 4, which is the only danger anticipated.

Dike 5, as has been stated in previous reports, crossed a small tow-head, which last year proved a weak point, the tow-head being cut in two just below the dike, and producing a break in its continuity, which it will be necessary to fill. When this dike is restored and dike 4 raised, (which last need not be done unless the tendency of the channel demands it,) the system of dikes perpendicular to the current will be practically complete to an extent justifying the commencement of a training wall to connect the outer ends.

In European river improvements these training-walls have been found necessary to success, and this improvement has often been sharply criticised because all the work hitherto done has been upon a series of perpendicular dikes or wing-dams, which, of themselves have been always found unsatisfactory, and the question is often asked, why the longitudinal dike has not been built. The reason is, that in all cases the longitudinal dike mus be connected with the bank by cross-dikes, and the order of construction must be governed by circumstances. In a narrow stream, where the longitudinal dike can in no place be more than a few hundred feet from the bank, the construction of the cross-dikes is a matter so easy that they may well be made numerous, and be built as the longitudinal dike progresses, or even after it. But in a wide river, where the improvement contemplates narrowing the bed nearly one-third, or even one-half of its width, it would not be prudent to follow the precedent of smaller streams too closely. With unlimited supplies of means it might be possible to carry on both kinds of work with equal steps; but, (as is the case with all Government works in the United States,) when appropriations bear no fixed relation to estimates, it is necessary to conduct the work so as to secure results, although the conductor may be well aware that under other conditions the work could be better done another way.

If, then, but one kind of work can be done at a time, which is the better: to build cross-dikes first, which will have a certain effect in pushing the channel toward its desired position, though not as complete as desired, and await the opportunity to construct the training-wall; or to build the wall first, which for great part of its length must be far out from the bank, and incur the probability of the channel getting upon the wrong side of it, a danger only to be averted by making the longitudinal dike high and massive?

The contemplated training-wall in this case must eventually extend from the ferry dike, opposite Carondelet, to the western side of Carroll's Island, opposite quarantine, a distance of 21,000 feet. Consideration of its cost per running foot will sufficiently answer the question of order of construction, for a low training-wall will cost $5 or $6 a foot, and the higher near $20. This answer was and is deemed conclusive. The cost of this training-wall has never distinctly appeared in the estimates, being classed with protective works, estimated in the aggregate at $4,000,000, (see Report of Chief of Engineers, 1875, volume 2, Appendix C C, page 492;) this particular estimate is $126,000. The wall, as estimated, is designed to restrict the channel within the lines at low-water, but not to be high enough to be itself exposed to injury by ice.

The expenditures during the year were—

Dike No. 1:	
28 mooring-piles	$188 11
11,268.6 cubic yards riprap, raising the dike from 6 feet to 15 feet above low-water	12,996 68
Engineering and contingencies	490 90
	13,675 69

Dike No. 2:

21 mooring-piles	$141 10
5,357.3 cubic yards riprap, raising the dike to 14 feet above low-water for a distance of 1,060 feet	5,983 04
Engineering and contingencies	223 41
	6,347 55

Dike No. 3:

24 mooring-piles	$161 24
19,832.5 cubic yards riprap, raising the dike to 13¼ feet above low-water for a distance of 1,335 feet	22,554 70
Engineering and contingencies	842 87
	23,558 81

Dike No. 4:

2,306 cubic yards riprap at shore end revetments and stem of dike	$2,548 14
Engineering and contingencies	93 80
	2,641 94

Dike No. 5:

5,626 cubic yards riprap placed in breach made by washing away of tow-head.	$6,437 77
Engineering and contingencies	242 79
	6,680 56

All work was done by hired labor with material purchased in open market.

It is proposed to continue the repairs of dike 5, to raise dike 4, and to commence a section of longitudinal dike the present season, with funds now available.

FORT CHARTRES DAM.

No work has been done at this dam, which is in good condition, though incomplete. In order to preserve the favorable condition of channel in this vicinity the revetment of a portion of Fish Bend will be necessary, and also part of the Illinois shore opposite the island. Length of protection necessary, 18,000 feet, at an estimated cost of $234,000.

TURKEY ISLAND DAM.

A small amount of work was done at this dam in October, 1876, toward filling the prism. The site is inaccessible when the river is low; consequently work can only be done on it at intervals. The work already done is in fair condition. No work is contemplated here the present season.

The expenditures were—

1,865.75 cubic yards riprap	$2,559 18
Engineering and contingencies	414 21
Total	2,973 39

KASKASKIA BEND.

The specific sum set apart in the act of August 14, 1876, having been withheld until April 19, 1877, no work has been done. The caving has progressed rapidly since the special report was made. The least distance between the two rivers March 18, 1876, was 2,080 feet; on May 16, 1877, it was reduced to 1,504 feet, since which time it is reported that the caving continues. The caving during low stages was located nearer the head of the bend than was anticipated when the report was written.

The amount available will, therefore, be applied to that part of the bend the coming fall. It will be necessary to continue the work until the whole distance estimated is protected, requiring further appropriations to amount of $37,000.

REVETMENT NEAR LIBERTY ISLAND.

This revetment, commenced in 1875, has been extended during the year 2,700 feet, making the length of bank now partially protected to the height of about 12 feet above low-water, 6,474 feet, which covers the most important part of the caving. It would be desirable to carry the revetment higher up the bank, but no funds are now available for the purpose. An allotment of $15,000 is desired to continue the work.

The expenditures during the year were—

11,607.82 cubic yards riprap	$17,254 17
Engineering and contingencies	1,215 12
Total	18,469 29

DEVIL'S ISLAND.

Work at Devil's Island was resumed March 7, 1877, and continued until the 15th of April, when it was suspended on account of the quarry being flooded. An erosion occurring at the east end of dam No. 2 during the latter part of April and first of May, endangering its connection with the shore, caused the necessity of procuring stone at the stages then prevailing. In order to do this a berme was raised at the quarry to 27 feet above low-water, thereby rendering it available at that and lower stages.

Following the order in which the work here was done, the work of March and April was on revetment above and below dike No. 1. That above was extended to the length originally contemplated, say 1,000 feet, and was raised to about 15 feet above low-water. Its height is not very regular, however, as the stage of water changed frequently while the work was being done, and was above the height contemplated for the revetment part of the time. Therefore this revetment may need some labor to trim it when the stage of water renders it practicable.

Below the dike 250 feet was revetted to the top of the bank, covering the space originally protected by spur-dikes. The spurs had been damaged to such extent as to seriously impair their usefulness. Scouring had reached such depths that repairing the dikes, so as to restore their usefulness, would have been very expensive. It was considered better to cover the space to be protected with a continuous revetment, and to use the available stone from the dikes in the revetment.

Expenditures were as follows:

5,308.91 cubic yards riprap	$7,591 74
Engineering and contingencies	459 75
Total	8,051 49

The next work in order of time was repairing and raising dam No. 2, which was done in the latter part of May and first of June. The east bank was revetted 400 feet above and 250 feet below the dam, and rising from low-water level at either end to the top of bank at the dam. The east end of the dam was extended well back into shore; the west end strengthened, and the dam slightly raised. It may be desirable to raise it more at a lower stage of water, when the work can be economi

cally done. The stage of water was not unfavorable when work was suspended there, but we changed to dam No. 1 in order to secure its east end while it was accessible, and since then the river has risen so much that it is unfavorable for work at both dams.

The expenditures appear as follows:

3,615.79 cubic yards riprap	$5,170 58
Engineering and contingencies	596 26
Total	5,766 84

Work was commenced on dam No. 1 June 21, and continued to the close of the month. The east end was strengthened so as to be considered secure, unless a radical change in the direction and velocity of currents should take place. Work of filling the gap was well advanced towards completion, but as the gap is widening slowly it is difficult to estimate how much stone will be required to complete it. It commences at a point about 400 feet from the east end of the dam and extends 250 feet westerly, and was a dry bar when the dam was built, in 1875, the bar extending at that time 650 feet from the east shore. This is not the gap left at close of the working season of 1875 near the west end of the dam, which was filled with sand during the high-water of 1876, the top of the sand being now about 24 feet above low-water.

Expenditures were—

2,017.95 cubic yards riprap	$2,885 67
Engineering and contingencies	299 23
Total	3,184 90

The work remaining to be done on the works commenced in this vicinity will probably be filling a gap near shore in dike No. 1; filling the gap in dam No. 1, and raising dam No. 2 to 14 feet above low-water; and among works for preservation, the protection of Minton's Point should receive favorable consideration when other allotments are made

DICKEY ISLAND TO MOUTH OF THE OHIO.

Under the provision of the act of August 14, 1876, requiring $30,000. to be expended within the limits above specified, work was begun in October last and continued until the close of the season. The plan described in the special report dated February 5, 1876, was followed with successful results. The eddies between the old spur-dikes which were being enlarged and threatening to break through the main levee in the rear of Cairo were stopped, and about 500 feet of bank above them partially protected, the total length of bank protected being 1,500 feet. Owing to the sudden closing of navigation the revetment was not made as high as intended, but the condition of the work when last visited was unchanged. A considerable balance of the allotment remains available, which will be applied this fall to raising and extending the protection. It is very important that the work so begun should be extended as soon as possible to the full extent estimated, requiring further appropriations to the amount of $142,000.

The expenditures were—

156 piles	$800 79
2,234.78 cords brush	6,468 22
5,162.21 cubic yards riprap	8,861 80
Engineering and contingencies	2,548 57
Total	18,679 38

Reviewing the results of the efforts to improve this section of the river since their beginning in 1872, we have to admit that some expectations have not been realized, because too much was expected by ourselves as well as by the public. Many contingencies have arisen which have increased the cost of individual works beyond what was hoped; still it can be said that as yet it has not been necessary to exceed the estimated sum at any locality. Looking forward to future work it is suggested that unless Congress is disposed to grant more liberal appropriations than have been given hitherto, it will be advisable to modify the plans and limit each year's work to one or at most two localities, and take up new undertakings only as those now begun are completed. In 1874, in confidence that the report of the select committee of the Senate would result in the prosecution of improvements on a liberal scale, the field of operations was considerably enlarged. Since then the act of March 3, 1875, led to the commencement of work at Piasa and Liberty Islands, and that of August 14, 1876, ordered further expansion of the field by works at Cahokia Chute, Kaskaskia, and near Cairo. As a consequence of these congressional orders, some of the works previously begun have remained untouched for the want of the funds diverted to new works which were ordered, while the whole appropriation remained at the uniform figure of $200,000 annually, except in the case of Cahokia Chute, for which special provision was made.

By commencing works the Government has committed itself at a number of points, and awakened expectation that something useful will be done at each; if these works stop or progress slowly, these expectations are disappointed and complaints are made against the administrative bureau, which, if justified at all, should rest upon the legislative branch of the Government. So far as the matter is left to the discretion of the engineer in charge the policy hereafter must be to devote all available means to the prosecution of works already begun, to the entire exclusion of all new undertakings until these are complete.

It cannot be disputed that there are new works needed at several points as urgently as those now in hand, but the financial limit is absolute and the engineers not at fault.

The estimated amounts required to complete works already begun are—

Piasa Island Dam, begun in 1875, virtually ordered by Congress	$17,474 36
Alton Dam, begun in 1872, virtually ordered by Congress	7,935 15
Sawyer Bend protection, begun in 1872, virtually ordered by Congress	50,270 95
Venice Dikes, begun in 1872, virtually ordered by Congress	3,658 15
Closing Cahokia Chute, begun in 1876, virtually ordered by Congress	83,641 39
Horsetail Bar, begun in 1873, not ordered, but most important work on whole section	19,606 41
Horsetail Bar protective work, not begun, but essential	126,000 00
Fort Chartres, begun in 1874, not by order	9,750 00
Turkey Island, begun in 1874, not by order	8,101 61
Kaskaskia, ordered in 1876, not yet begun	37,000 00
Liberty Island, ordered in 1875, virtually by provision	8,140 71
Devil's Island, not by order, 1874, very necessary	30,026 14
Cairo protection, ordered in 1876	153,820 62
Appropriations required to finish	555,425 49

It will be seen that the works undertaken under the discretionary authority of the Bureau of Engineers in 1873 and 1874 require to complete them $193,484.16, and that the balance of the estimate, $361,941.33, is for works ordered directly or by implication by Congress. Of these latter,

Sawyer Bend	$50,270 95
Kaskaskia	37,000 00
Liberty Island	8,140 71
Cairo	153,820 62
	249,232 28

are protective works for which the principal influence toward obtaining the order came from local interests. In order that the proper committees may have before them the full extent of the possible field for such applications, a list of localities is given where the banks are caving to a greater or less degree, covering the river from the Missouri to the Ohio:

Opposite mouth of Missouri	36,000 feet caving moderately.
Sawyer Bend	27,000 feet caving moderately.
Above Widow Beard's Island	14,000 feet caving slowly.
Near Smith's Landing	17,000 feet caving fast.
Near Harrisonville	5,000 feet caving slowly.
Near Harlow's or Perry's Towhead	17,000 feet caving slowly.
Fish Bend	20,000 feet caving very fast.
Fort Chartres Landing	15,000 feet caving slowly.
Big Fields below Saint Genevieve	17,000 feet caving slowly.
Kaskaskia and vicinity	21,000 feet caving very fast in part.
Bois Brule, below Saint Mary's	27,000 feet caving slowly.
Liberty Island	26,000 feet caving slowly.
Above Big Eddy	14,000 feet caving rapidly.
Grand Tower Island	21,000 feet caving slowly.
Near Poe's Landing	9,000 feet caving slowly.
Minton's Point	4,000 feet caving rapidly of late.
Cape Girardeau Bend	19,000 feet caving very slow.
Dog Tooth Bend	20,000 feet caving moderately.
Thompson's	6,000 feet caving moderately.
Greenleaf's Bend	25,000 feet caving rapidly.
Dickey Island to Ohio	17,000 feet caving rapidly.
Bird's Bend	30,000 feet caving rapidly.
	407,000 feet.

In addition to these, which are all confined to the main bank, there would be engineering reasons for the protection of islands at various points in direct connection with improvements of the channel, amounting in the aggregate to 80,000 feet, to which may be added the work of defining the eastern limit of the river in front of Saint Louis, and extending to Carroll's Island, 63,000 feet, making a total length of 550,000 feet, the cost of which will vary from $6 to $20 per foot. Taking the mean at $13, there is a total estimate of $7,150,000. Of this aggregate, (by shortening the measurements to what would probably be necessary to protect,) 327,000 feet remains as the estimate of necessary protections, which, at $13 per foot, as above, would cost $4,251,000, which is reasonably near the approximate estimate of $4,000,000 given in the report on transportation routes, Report of Chief of Engineers, 1875, Part II, page 492.

SURVEYS.

No surveys were made except such as were required for the final location of new works at Cahokia Chute and near Cairo, and a partial resurvey at Horsetail Bar, in connection with the work at that locality.

EQUIPMENT.

No additions have been made to equipment during the year. Two of the barges first purchased having become worthless for further service were sunk to form part of foundations; the remainder of property is on hand and most of it is in good condition for further service; but three more of the old barges will have to go out of service the coming year, being too old for repairs. As this will reduce the number of serviceable

barges below the requirements of the work, it is hoped that appropriations will allow the purchase or construction of four new barges, at an estimated cost of $13,000, the ensuing year.

The prosecution of the works the last season by purchase of material in open market and by hired labor has been very satisfactory, material having cost fully one-fifth less than it was ever obtained for by contract, and in quantities so large as to materially reduce the cost of transportation. The competition in open market is very sharp, and successful competitors are much more closely bound by the consideration that others would gladly take their place, than by a nominal bond which all experience shows will not be enforced; besides, payments monthly in full make it easier to carry on the furnishing of material than if a percentage is retained, an advantage which enables material to be procured at more favorable rates.

STATISTICS.

In obedience to the requirements of the circular from the Chief of Engineers, dated March 9, 1877, a special effort was made to obtain statistics of the commerce of this portion of the Mississippi River. In addition to the general movements in the direction of the river, information was also obtained concerning the movements of freight across the Mississippi by ferry and transfer of cars by water in order to show the importance of the harbor-facilities at Saint Louis in relation to the business of the railroads, a relation which has heretofore received little attention, although, as will be seen by reference to the statistics, this transfer business is in proportion to the river freightage proper as eight to ten nearly. The labor of obtaining and compiling the statistics, which has been very considerable, was done by my chief clerk, S. S. Hutchins, whose report is appended hereto, and to which I respectfully refer.

The work is located in the collection-district of New Orleans.

The amount of revenue collected at the port of Saint Louis for the fiscal year ending June 30, 1877, was $1,422,642.93.

Construction account.

Name of work.	Amount expended previous to July 1, 1876.	Amount expended during year ending June 30, 1877.	Total cost to June 30, 1877.	Amount required to complete.	Total estimated.
Piasa Island Dam	$16,210 73	$7,525 64	$23,736 37	$17,474 36	$41,210 73
Alton Dam	31,368 45	696 40	32,064 85	7,935 15	40,000 00
Sawyer Bend protection	91,940 67	....	91,940 67	50,270 95	142,211 62
Venice Dikes	36,341 85	....	36,341 85	3,658 15	40,000 00
Closing Cahokia Chute	....	20,958 61	20,958 61	83,641 39	104,600 00
Horsetail Bar, dike 1	26,873 84	13,675 69	40,549 53		
Horsetail Bar, dike 2	15,564 03	6,347 55	21,911 58		
Horsetail Bar, dike 3	47,506 81	23,558 81	71,065 62	19,606 41	221,502 56
Horsetail Bar, dike 4	38,648 17	2,641 94	41,290 11		
Horsetail Bar, dike 5	20,399 05	6,680 56	27,079 61		
Fort Chartres Dam	36,812 86	....	36,812 86	9,750 00	46,562 86
Turkey Island Dam	21,490 46	2,973 39	24,463 85	8,101 61	32,565 46
Liberty Island Dam	5,053 91	....	5,053 91	....	5,053 91
Liberty Island protection	16,647 68	18,469 29	35,116 97	8,140 71	43,257 68
Devil's Island, dike 1	50,416 89	8,051 49	58,468 38		
Devil's Island, dam 1	43,084 06	3,184 90	46,268 96	30,026 14	150,000 00
Devil's Island, dam 2	9,479 18	5,766 84	15,246 02		
Cairo protection	....	18,679 38	18,679 38	153,820 62	172,500 00
Totals	507,838 64	139,210 49	647,049 13	392,425 49	1,039,465 12

NOTE.—The changes made in first column from amounts shown in report for previous year consist of unimportant errors then made, and are due to that statement being hastily prepared in advance of the records being fully written up.

Property and material account.

Class of property.	Balance July 1, 1876.	Dr.	Cr.	Balance July 1, 1877.
Office furniture	$500 55	....	$120 00	$380 55
Instruments and survey material	850 00	$3 00	3 00	850 00
Five pile-drivers	10,071 39	398 12	259 00	10,210 51
Sixteen barges and one quarter-boat	40,339 46	3,129 36	13,499 22	29,969 60
Two tow-boats, one small tug and expenses	56,402 84	21,729 55	30,870 02	47,262 37
Small boats	166 82	104 17	175 00	95 99
General expenses of property	13,495 49	4,555 59	....	18,051 08
Material and quarry privileges	1,961 70	110,671 27	109,824 99	2,807 98
Tools	1,915 00	2,516 10	3,437 28	993 82
Quarters for workmen, shops, &c	2,177 79	2,161 91	759 00	3,580 70
Totals	127,881 04	145,269 07	158,947 51	114,202 60

Engineer Office, United States Army, in account with United States.

Dr.		Cr.	
To allotments for surveys and examinations at various dates prior to July 1, 1876	$48,008 77	By expenses of office	$39,353 64
To appropriations for improvement of the Mississippi River between the Illinois and Ohio Rivers prior to July 1, 1876	725,000 00	By general engineering	25,871 38
To appropriation for improvement of channel of Mississippi River opposite Saint Louis, (closing Cahokia Chute,) approved August 14, 1876	29,600 00	By surveys	75,531 58
To appropriation for improvement of Mississippi River between Illinois and Ohio Rivers, approved August 14, 1876	200,000 00	By constructions	647,049 13
To unpaid percentage on annulled contracts	900 17	By balance on account of property	114,202 60
To liability for labor, (non-payment account)	4,781 85	By cash on hand and in Treasury	106,404 14
To liability for material	112 67		
To liability for office supplies	9 00		
Total	1,008,412 47	Total	1,008,412 47

Money statement.

July 1, 1876, amount available	$15,724 68	
Amount appropriated by act approved August 14, 1876	229,600 00	
		$245,324 68
July 1, 1877, amount expended during fiscal year	138,920 54	
July 1, 1877, outstanding liabilities	5,803 69	
		144,724 23
July 1, 1877, amount available		100,600 45
Amount (estimated) required for completion of existing project		6,729,600 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		500,000 00

COMMERCIAL STATISTICS.

UNITED STATES ENGINEER OFFICE,
Saint Louis, Mo., July 24, 1877.

GENERAL: To comply with instructions from the Chief of Engineers, requiring a statement of statistics of commerce of the Mississippi River between the mouths of the Illinois and Ohio Rivers, you issued, April 2, 1877, a circular requesting information upon the subject. This circular was forwarded to persons engaged in business at all points along the river within those limits except Saint Louis, and requested each to fill up and return a blank form sent with it, showing their receipts and shipments by river of all articles in alphabetical order, with estimated value of each, during the year 1876.

The number of circulars distributed and responses received appears as follows:

Locality.	Circulars sent.	Responses received.
Grafton, Ill	10	4
Portage des Sioux, Ill	3	......
Alton, Ill	77	39
Harrisonville, Ill	2	1
Prairie du Rocher, Ill	1	1
Saint Genevieve, Mo	28	15
Saint Mary's, Mo	13	4
Kaskaskia, Ill	3	.....
Chester, Ill	25	10
Rockwood, Ill	4	2
Wittenburg, Mo	7	2
Grand Tower, Ill	9	9
Cape Girardeau, Mo	41	41
Commerce, Mo	7	3
Rush Power, Ill	1	1
Cairo, Ill	1	1
Total	232	133

From the information thus received, and from that contained in the published report of Mr. George H. Morgan, secretary of the Merchants' Exchange of Saint Louis, with additional data obtained from him and other sources, the accompanying statement has been compiled, and is submitted with the following explanatory remarks:

This statement shows approximately for all points between the Illinois and Ohio Rivers.

Receipts, tons	1,222,631	$38,000,716 40
Shipments, tons	874,099	60,761,262 84
Total, tons	2,096,730	98,761,979 24

The above total, however, is evidently less than the true amount, since of the 232 persons called upon 99 failed to respond, though full returns are included of Saint Louis, Grand Tower, Cape Girardeau, and Cairo, which cover over 95 per cent. of the whole.

It may be stated, too, that the destination of shipments from the several points is unknown; hence, in summing up the receipts, some items are necessarily repeated; yet as Saint Louis, which represents the greater tonnage and value, is doubtless the destination of nearly all these items, the result would not be disturbed to any appreciable extent.

Some replies to the circular contained no weights, but gave quantities of certain items in the most convenient unit with value, while others specified quantities or weights, and omitted value. The difficulty in determining deficient weight and value in some of these cases was overcome by assuming the unit of weight or value supplied by other returns, and applying the same to like items where not given. The report of the secretary of the Merchants' Exchange of Saint Louis and the files of the Saint Louis Market Reporter aided also very materially in fixing average prices and weights per unit of many of the leading articles.

Special requests were made for information showing the tonnage and value of the ferry and harbor business of Saint Louis, of which full returns were furnished, but a portion of them were deficient in detail, presenting the information in a manner too general to admit of its use without aid from other sources. That given, however, with the weights and values per unit of many articles of merchandise transported, already ascertained, furnished the data from which the inclosed estimated statement was prepared.

The aggregate of this statement shows 1,627,083 tons, with a value of $79,695,928, which, added to the receipts and shipments for all points on the Mississippi River between the Illinois and Ohio Rivers, as shown above, gives a grand total of 3,723,813 tons, with a value of $178,457,907.24.

Of course, as has been demonstrated, absolute accuracy is not claimed for this result; but, considering the character of the information, and the method of putting the same in shape, it is hoped it will aid in conveying an approximation to the extent and value of the tonnage of the river within the limits stated.

Very respectfully, your obedient servant,

S. S. HUTCHINS.

Gen. J. H. SIMPSON,
Colonel of Engineers, U. S. A.

Statement showing approximately the extent and value of commerce of the Mississippi River between the mouths of the Illinois and Ohio rivers for the year ending December 31, 1876.

Locality.	Receipts.		Shipments.	
	Tons.	Estimated value.	Tons.	Estimated value.
Grafton, Ill	3,038	$157,159 00	39,445	$226,825 00
Portage des Sioux, Ill. *	....	....	....	....
Alton, Ill	43,700	1,104,687 26	13,468	943,287 94
Saint Louis, Mo	1,143,806	34,478,175 17	607,769	55,745,837 55
Harrisonville, Ill	655	40,884 15	5,684	95,439 45
Prairie du Rocher, Ill	535	7,091 00	2,431	141,551 00
Saint Genevieve, Mo	3,934	228,653 47	46,570	541,224 52
Saint Mary's, Mo	3,109	8,918 00	3,894	199,505 00
Kaskaskia, Ill. *	....	....	....	....
Chester, Ill	5,828	123,043 30	5,544	275,012 70
Rockwood, Ill	360	16,525 00	1,229	65,392 50
Wittenburg, Mo	296	153,516 75	3,928	225,622 00
Grand Tower, Ill	1,047	356,240 84	41,508	339,109 85
Cape Girardeau, Mo	2,003	395,331 46	16,138	1,015,408 41
Commerce, Mo	111	36,135 00	838	28,469 00
Rush Tower, Ill	4,124	116,500 00	....	....
Cairo, Ill	10,085	777,856 00	85,653	918,577 92
Total	1,222,631	38,000,716 40	874,099	60,761,262 84

* No returns received.

Statement showing approximately the extent and value of ferry and harbor transportation at Saint Louis, Mo., during the year ending December 31, 1876.

	Tons.	Estimated value.
General merchandise transported by ferries both ways across the Mississippi River at Saint Louis	1,437,470	$79,255,596 40
Coal moved in harbor of Saint Louis	148,188	371,263 04
Stone moved in harbor of Saint Louis	41,425	38,626 31
Towing in harbor of Saint Louis	....	30,442 25
Total	1,627,083	79,695,928 00

Empty cars, empty wagons, carriages, and buggies with teams and passengers, not included.

APPENDIX O.

ANNUAL REPORT OF LIEUTENANT EDWARD MAGUIRE, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1877.

UNITED STATES ENGINEER OFFICE,
HEADQUARTERS DEPARTMENT OF DAKOTA,
Saint Paul, Minn., June 30, 1877.

GENERAL: I have the honor to submit herewith my annual report for the fiscal year ending June 30, 1877.

Very respectfully, your obedient servant,

EDWD. MAGUIRE,
First Lieutenant of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

IMPROVEMENT OF MISSOURI RIVER ABOVE THE MOUTH OF THE YELLOWSTONE.

A letter from the office of the Chief of Engineers dated March 21, 1877, informed me that, in addition to my other duties, I was placed in charge of the work of improving the Missouri River above the mouth of the Yellowstone.

Upon investigation I found that there were three reports upon this subject: One by Maj. Charles R. Suter, Corps of Engineers, (Report of the Chief of Engineers, 1875;) one by Capt. C. W. Howell, Corps of Engineers, (Report of the Chief of Engineers, 1868;) and one by Mr. Thomas P. Roberts, published by the War Department in 1875. Each of these reports recommended improvements in but general terms. As no detailed surveys have ever been made, it was impossible for them to do otherwise. Still they are definite enough to show that the work should be commenced in the upper portion of the river within the first 300 miles from Fort Benton, where the obstructions to navigation consist of a series of rapids difficult of passage in consequence of the slight depth at low-water stage and the rapidity of the current. Of these rapids Dauphin's, Cow Island, and Two-Calf Island are mentioned in the reports as demanding the first attention, and the opinions of steamboatmen, as expressed to me, coincide with that conclusion. Of these three, Dauphin's Rapids present the greatest difficulties.

In view of the above a party, consisting of one assistant engineer, one recorder, one overseer, and twenty-three men, was organized in this city and started for Dauphin's Rapids on the 11th instant.

The remoteness of the scene of operations from all depots of supplies and the uncertainty of the time of arrival and departure of the steamboats necessitated the purchase at once of material of such a nature and

in such quantities as to supply all needs in any contingency which may arise.

An escort of one company of the Seventh Infantry was requested, and it was ordered to meet the working party at Dauphin's Rapids not later than the 25th instant. In addition I obtained, upon requisition on the chief ordnance officer of the Department of Dakota, 24 rifles and 3,000 rounds of ammunition for use by the party in an emergency.

Permission was obtained for the purchase of the rations from the subsistence depot at Fort Buford, and the rations will be drawn for sixty days at a time.

Water-gauges will be established and a detailed survey of the immediate locality of the work will be made directly after the arrival of the party. Gauges will also be established at Carroll and Fort Buford if any one can be found at those points who will, for a reasonable compensation, keep a record of the stage of water. The assistant engineer was furnished with a thermometer and an aneroid barometer, and it is hoped that it may be possible to run a line of levels between the points. By the above means it is thought that information more detailed than that which we now possess of the nature and habits of the river will be obtained.

The main work will consist in procuring a channel of a width of 300 feet, if practicable, and of a depth of 4 feet at low-water stage. This will necessitate the removal of reefs, bars, and bowlders by "grabbing" or blasting, and the construction of wing-dams of brush or stone so disposed as to obtain a sufficient amount of water and diminish the velocity of the current, if found to be necessary. For the work there will be used one scow rigged with a derrick and "stone-grab," one dwelling-boat, one working-boat, and one yawl, or "batteau," as it is termed by the lumbermen in this section of the country.

The party will move the escort and itself from point to point by means of these boats. It is expected that at least the work on the three points mentioned above will be completed during the coming season.

At the close of operations the material will be stored at Carroll, in order to be at hand, and to save the expense and trouble of transportation in case there should be an appropriation to continue the work another year.

I would respectfully recommend that the work during the season of 1878 and 1879 be commenced at the Marias Rapids, and, proceeding down stream, clear the channel at Hip's Rapids, Drowning Man's Rapids, Snake Point, Bird, Bear, and Lone-Pine Rapids, and Grand Island. For this purpose I would recommend that $30,000 be appropriated, as it is believed that that amount can be profitably expended.

The portion of the river between the rapids and the Yellowstone has not been referred to, because, as stated above, it is a well-settled opinion that the stretch in which the rapids occur should receive the first attention, and there will be a sufficient amount of work in that section to occupy a party for another season.

Money statement.

Amount appropriated by act approved August 14, 1876		$20,000 00
July 1, 1877, amount expended during fiscal year	$4,589 33	
July 1, 1877, outstanding liabilities	951 04	
		5,540 37
July 1, 1877, amount available		14,459 63
Amount that can be profitably expended in fiscal year ending June 30, 1879.		30,000 00

SUPPLEMENTARY REPORT.

COW ISLAND, MONT., *September* 18, 1877.

GENERAL: I have visited the party at work at Dauphin's Rapids, and have found that the work is not only more difficult, but far more extensive than was to be expected. The bed of the stream is almost literally paved with bowlders for a distance of at least half a mile. I was led to believe, from Roberts's report, that there were but few bowlders scattered here and there through the channel.

I have also learned that there are other points above Dauphin's which must be improved before the river will be navigable in low-water. There are seventeen places above Dauphin's which should be attended to.

In view of this, I would request permission to change the recommendation (contained in my annual report) for an appropriation of $30,000 to one of $75,000.

With this amount three parties can be worked to good advantage, and there can be purchased for each party a small engine, a thing that is very much needed for working the rakes and facilitating the operations in other ways.

I have been unable to send this letter earlier, on account of the want of any means by which to do so.

Very respectfully, your obedient servant,

EDWD. MAGUIRE,
Lieutenant of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

APPENDIX P.

ANNUAL REPORT OF COLONEL J. N. MACOMB, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1877.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., July 12, 1877.

GENERAL: I beg leave to submit herewith the annual reports upon the several works in my charge for the fiscal year ending on the 30th June, 1877, together with the estimates for continuation or maintenance of these works for the fiscal year ending on the 30th June, 1879.

In submitting these reports the importance of the channels of communication afforded by the upper Mississippi and Illinois rivers is clearly shown by the information given under the head of "statistics of commerce and navigation," in the report of Assistant C. W. Durham, upper Mississippi River, and under the head of "statistical and commercial information," in the report of Assistant R. A. Brown, Illinois River. And as the works for improving the navigation, which are in progress or are contemplated on different points on the Upper Mississippi River, are all to be regarded as having for their chief object the perfecting of the through navigation, the commercial exhibits above referred to are deemed sufficient to justify the outlay for all the separate works, which indeed may be regarded as but parts of the general scheme of improving the upper Mississippi River.

I remain, very respectfully, your most obedient servant,

J. N. MACOMB,
Colonel of Engineers, U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

P 1.

IMPROVING UPPER MISSISSIPPI RIVER.

The Montana, United States snag and dredge boat, has been employed in removing snags, leaning trees, and building low dams for the permanent improvement of the Mississippi River. The allotment of the season of 1876 of $10,000 was not sufficient to keep her running all summer, but much useful work was done in the collection of commercial statistics, of which tables were compiled by Assistant Engineer C. W. Durham, and give a very full statement of the commerce of the Mississippi River.

The resignation of Capt. John B. Davis, formerly captain of the *Montana*, made a vacancy to which Mr. C. W. Durham was appointed. The experience of Mr. C. W. Durham in the surveys of the upper Mississippi River, and his good management and executive ability, make him

a peculiarly fit person for this position. The pilot of the *Montana*, Mr. David Tipton, is considered one of the best river experts on the upper Mississippi.

June 1, United States Civil Engineer M. Meigs was ordered to report to me for duty in connection with the improvement of the upper Mississippi, and was given general supervision of the works mentioned below:

Improvement of the upper Mississippi River; improvement of the harbor of Fort Madison, Iowa; improvement of Rush Chute, and the harbor of Burlington, Iowa; removal of a bar in the Mississippi River opposite Dubuque, Iowa.

Mr. Durham's report up to June 8, 1877, and Mr. Meigs's report thereafter, give in detail the work performed by the *Montana* for the fiscal year ending June 30, 1877.

ESTIMATE.

For new iron hull, steel boilers, transfer of machinery, and rebuilding the Montana	$66,500 00
For current expenses of the "Montana" for the fiscal year ending June 30, 1879	25,000 00
Total	91,500 00

Money statement.

July 1, 1876, amount available	$1,609 86
Amount appropriated by act approved August 14, 1876	30,000 00
	31,609 86
July 1, 1877, amount expended during fiscal year	14,857 65
July 1, 1877, amount available	16,752 21
Amount that can be profitably expended in fiscal year ending June 30, 1879.	91,500 00

The improvements at Keokuk and at Rock Island are now near completion, and the encouragement of steamboat navigation seems to demand that some system of improvement shall be applied to the obstructions by shoals and sand-bars, which will hereafter be the controlling features of navigation. Mr. Meigs and Mr. Durham, in their reports appended below, give reasons for these improvements, and the following

ESTIMATE.

For construction of permanent improvements at shoals in the Upper Mississippi, by building brush and riprap dams, all of which can be profitably expended during the fiscal year ending June 30, 1879	$75,000 00

Money statement.

Amount (estimated) required for completion of existing project between Saint Paul and Montrose	$617,393 01
Amount that can be profitably expended in fiscal year ending June 30, 1879	75,000 00

IMPROVEMENT OF THE HARBOR OF FORT MADISON, IOWA.

The contract for furnishing stone for this work has been let, and the work will be begun immediately. Mr. M. Meigs, whose report is herewith submitted, estimates that—

The completion of the work will need the balance of the original estimate.	$30,186 87
Appropriated August 14, 1876	10,000 00
Balance	20,186 87

all of which can be advantageously applied in the fiscal year ending June 30, 1879.

Money statement.

Amount appropriated by act approved August 14, 1876		$10,000 00
July 1, 1877, amount expended during fiscal year	$312 55	
July 1, 1877, outstanding liabilities	50 88	
		363 43
July 1, 1877, amount available		9,636 57
Amount (estimated) required for completion of existing project		20,186 87
Amount that can be profitably expended in fiscal year ending June 30, 1879.		20,186 87

IMPROVEMENT OF RUSH CHUTE, AND THE HARBOR OF BURLINGTON, IOWA.

The bids for furnishing stone for the beginning of this work have been advertised, and will be opened July 25, 1877. Mr. Meigs, in his report, which is herewith submitted, estimates that the completion of the work will require the balance of the original estimate, and it appears from a recent examination at the head of Rush Chute that the difficulties of navigation at that place are increasing.

ESTIMATE.

Original estimate	$35,221 70
Appropriated August 14, 1876	10,000 00
Balance	25,221 70

All of which can be advantageously expended in fiscal year ending June 30, 1879.

Money statement.

Amount appropriated by act approved August 14, 1876		$10,000 00
July 1, 1877, amount expended during fiscal year	$33 33	
July 1, 1877, outstanding liabilities	38 88	
		72 21
July 1, 1877, amount available		9,927 79
Amount (estimated) required for completion of existing project		25,221 70
Amount that can be profitably expended in fiscal year ending June 30, 1879.		25,221 70

REMOVAL OF A BAR IN THE MISSISSIPPI RIVER, OPPOSITE DUBUQUE, IOWA.

The contract for this work (dredging) will be let toward the latter end of July. The original project for this work has been changed, in consequence of altered local circumstances and the insufficiency of the appropriation, as set forth by U. S. Civil Engineer M. Meigs, in his report herewith presented.

It is proposed to remove the bar by dredging, to afford immediate relief, and to build a training-wall opposite to the mouth of New Barney Cut, to direct the water of the river parallel with the shore and prevent the formation of the bar in the future. The estimate for this last work is:

ESTIMATE.

20,000 cubic yards loose rock, at $1 per cubic yard	$20,000 00
Brush-work foundation	3,000 00
Engineering, contingencies, &c	2,300 00
Total	25,300 00

Money statement.

Amount appropriated by act approved August 14, 1876	$15,000 00
July 1, 1877, amount expended during fiscal year	583 18
July 1, 1877, amount available	14,416 82
Amount (estimated) required for completion of existing project	25,300 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	25,300 00

REPORT OF MR. C. W. DURHAM, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., June 8, 1877.

COLONEL: I have the honor to present my report on the Improvement of the upper Mississippi River, from June 30, 1876, to June 8, 1877.

OPERATIONS OF THE UNITED STATES STEAMER MONTANA.

On September 12, 1876, I received instructions from you to get the *Montana* ready for service, and continue operations for the improvement of the navigation of the upper Mississippi River.

A few days were consumed in making the necessary repairs, purchasing cordage and provisions, and shipping the crew; and, on September 23, the *Montana* got under way and proceeded up river, arriving at La Crosse on the evening of the 28th. On the way up we removed snags, leaning trees, and other obstructions at or near the following localities: Dark Slough, Maquoketa Slough, Hurricane Island, Cassville Slough, Glen Haven, Crooked Slough, and Brownsville.

On morning of September 29 we rigged up the shears and proceeded to a point about one-half mile below La Crosse, for the purpose of removing from the channel a large sunken barge. After 18 hours hard labor we succeeded in detaching it from its bed of sand, and towed it into shoal water outside of the channel.

On October 1 and 2 the crew of the *Montana* were employed in making an examination of the river in the vicinity of the new bridge of the Milwaukee and Saint Paul Railroad Company, near La Crosse, Wis., in the course of which work some 1,500 soundings were made.

On October 3 the *Montana* proceeded up river, arriving at Saint Paul on the evening of the 7th. Between La Crosse and Saint Paul large numbers of snags, leaning trees, &c., were removed at or near the following named localities: Dakota, Queen's Bluff, Winona, Argo Island, Wild's Landing, Fountain City, Rolling-stone Slough, Chimney Rock, Mount Vernon, Minneiska, Davis's Bend, West Newton Chute, Pine Island, Beef Slough, Crats's Island, Wabasha, Reed's Landing, and Diamond Bluff.

Left Saint Paul on morning of October 9, and ran down to Nininger Slough Bar, having made, on the way, an examination of the bar at Pig's-Eye Island, with a view to ascertaining the effect of the dam built in 1874 for the improvement of the bar. About five hundred soundings were taken. Some overhanging trees were also removed at Red Rock and Pine Bend. On the morning of October 10 began the construction of dam No. 2, across the mouth of a slough at Nininger Slough Bar which slough diverted a considerable body of water from the channel.

Dam No. 1 was built in 1875, about ½ mile farther up the river, across another slough, and it is thought that the combined effect of both dams will be to permanently improve navigation at this locality. The rock for dam No. 2 was quarried from Nininger Bluff, about 1 mile below the site of the dam, carried up on the bow of the "Montana," and put in position, the total amount being about 555 cubic yards. The dam was completed October 14.

On morning of 16th left Hastings and proceeded down the river, arriving at La Crosse about noon of the 18th. Snags were extracted and other work done between Hastings and La Crosse at or near the following points, viz, Half-moon Bend, Waconta, Read's Landing, Crats's Island, Beef Slough, Davis's Bend, Homer, Trempeleau, and Queen's Bluff. During the afternoon of the 18th made an examination of the various chutes below the new La Crosse bridge, in order to ascertain the changes in the volume of water passing through them, caused by the construction of the new bridge and the dam at the head of Minnesota Island; proceeded down river, arriving at Rock Island on the evening of October 21. On the way down worked in Coon Slough, and near De Soto, Cassville, and Bellevue. Left Rock Island on morning of the 23d, and proceeded down river to head of Des Moines Rapids, and thence returning arrived again at Rock Island about noon of the 28th. On the way up snags and leaning trees were removed at the following places, viz, in Rush Chute, at Devil's Island, Dallas Chute, mouth of Shokoken Slough, Saeurwein's Landing, Kaintuck's, near Oquawka, Johnson's Island, Keithsburg Chute, Denison's Landing, Bay Island, and in Muscatine Chute.

From October 28 to 31 a portion of the crew were employed in putting the boat in

readiness for winter, by unshipping the spars, housing the cordage, tackle, &c., painting the smoke-stacks, and caring for the machinery, so that no detriment or damage might ensue while the boat should be out of commission.

During the winter the Montana was hauled out on the ways at the Rock Island boat-yard, and her hull was repaired below the water-line.

Summary of operations of United States steamer Montana, season of 1876.

Miles run.	Trees felled.		Snags extracted.	Leaning trees pulled back.	Cubic yards of rock put in dam.	Soundings made.	Length of cruise.
	Large, 8 inches in diameter and over.	Small, under 8 inches in diameter.					
1, 184	438	2, 625	37	73	555	2, 340	6 weeks.

Also, two barges pulled off shore and set afloat, and one large sunken barge pulled out of the channel. The river being at a fair boating stage, during the time in which the *Montana* was in commission, it was not found necessary to use the scraper, and therefore the greater portion of the time was devoted to clearing the channel of snags and removing overhanging trees. The following table gives a summary of operations from 1868, the year in which the work was initiated, up to and including the season of 1876:

Improving Upper Mississippi River.—Summary of operations from 1868 *to* 1876, *inclusive.*

	Snags extracted.	Leaning trees removed.	Stumps extracted.	Steamboats, barges, and rafts pulled off bars.	Scrapes.	Miles run.	Remarks.
Season of 1868, Montana and Caffrey.	329	344	......	......	......	5, 904	
Season of 1869, Montana and Caffrey.	475	595	......	......	......	....	Water very high and boats employed but little. A small amount of dredging was done.
Season of 1870, Montana and Caffrey.	......	......	......	......	......	....	No detailed report.
Season of 1871, Montana and Caffrey.	465	656	33	33	3, 444	7, 292	Season four months. Built 1,600 feet of wing-dams.
Season of 1872, Montana and Caffrey.	550	2, 550	722	10	......	6, 730	Last season of the Caffrey.
Season of 1873, Montana..	3	16	2	11	......	2, 263	Piles driven and jetties constructed at Pig's Eye, Newport, Rolling Stone, and Betsy Slough.
Season of 1874, Montana..	13	45	2	2	......	3, 862	Three wrecks removed, Pig's Eye Dam built.
Season of 1875, Montana..	38	169	9	18	......	3, 535	Built dam No. 1 at Nininger Slough.
Season of 1876, Montana..	37	3, 136	......	2	......	1, 184	Built dam No. 1 at Nininger Slough. Removed sunken barge at La Crosse. Made several surveys. Season six weeks.

From 1868 to 1872, inclusive, two boats were employed, the *Montana* and the *Caffrey*; the former's field of operations extending from the mouth of the Illinois River to Lake Pepin, and that of the latter from Lake Pepin to Saint Paul. In 1872, the appropriation being small, the *Caffrey* was not put in commission, and was soon afterward sold. Since that time the *Montana* has worked over the whole ground above mentioned. From 1868 to 1872, inclusive, large numbers of snags, the accumulations of many years, were removed from the channel, and overhanging trees, threatening to fall into the river, were pulled back on shore or cut down. Since that time the number of snags found in the channel has been very small, owing to the policy of prevention adopted in clearing the shores of overhanging trees and those near the bank liable to cave into the river. The *Montana*, in 1876, extracted every snag between Saint Paul and the head of Des Moines Rapids, and the number was only thirty-seven. The river being at a good boating stage during the season, the scraper was not employed, and a great

deal of attention was paid to the shores in the bends and on the channel side of the river, not only the large trees being removed to a distance of 5 feet from the edge of the bank, but also the smaller ones, which often cause much trouble by sweeping off the deck-loads of barges, the channel being very close inshore at many places.

A considerable amount of this kind of work will be required each season to keep the river free from snags.

PERMANENT IMPROVEMENTS.

The *Montana*, in the time that she could be spared from her other duties, has with her small crew permanently improved two of the worst bars on the river, and a third has been eradicated by the Milwaukee and Saint Paul Railroad Company under your directions, as stated below.

1. *Pig's Eye Bar.*—This bar, caused by a diversion of the river into two channels by Pig's Eye Island, has been the terror of navigators since the river was first run by steamboats. But a few miles below, and in sight of Saint Paul, it was the cause of great loss and vexation to steamboatmen, who, when so near the end of their trip, were obliged to unload and transfer their cargoes to small boats and barges. Several attempts were made to improve the bar, but without success until the present existing dam was built in 1874. A survey of the locality was made in 1874, prior to the building of the dam, the results of which survey are embodied in sketch No. 1.

It will be seen that boats going up or down were obliged to pass over a shallow bar in either channel. On the bar at low stages there was but from 1½ to 2 feet of water, and even moderately large steamers were effectually blocked. The contour-lines show a sufficiency of water both above and below the bar. A channel had been repeatedly dredged through the bar, but the effect was only temporary, it being filled up again at the first rise in the river.

In October, 1874, a dam of loose rock was built from the head of the island over to the eastern shore, with its crest about 4 feet above low-water mark. The shore at either end of the dam was protected by riprap, as also the bank on the western shore, where the diverted and accelerated current impinged. A survey of the locality was again made in 1876, nearly two years after the building of the dam, the results of which are shown in sketch No. 2. A comparison of the two drawings will enable one to see clearly the changes caused by the building of the dam. A *permanent channel* has been cut through the bar with *sufficient* depth for the largest boats at the *lowest stages.* It may be stated that 3 feet at low water, as on the map, means 3 feet at low water of 1864, which is by far the lowest ever known, so that at ordinary low water there will be a wide channel of from 4 to 4½ feet in depth. There is at present much more water on Pig's Eye Bar than on many of the bars below, and if a boat can get up to Pig's Eye it can get over it to Saint Paul without difficulty. At extreme low water of 1876 there was a 5-foot channel over the bar, but large boats could not avail themselves of it, because they were stopped by bars miles below. The channel is also much straightened. This work is the most satisfactory to steamboatmen of any that has been accomplished on the upper river.

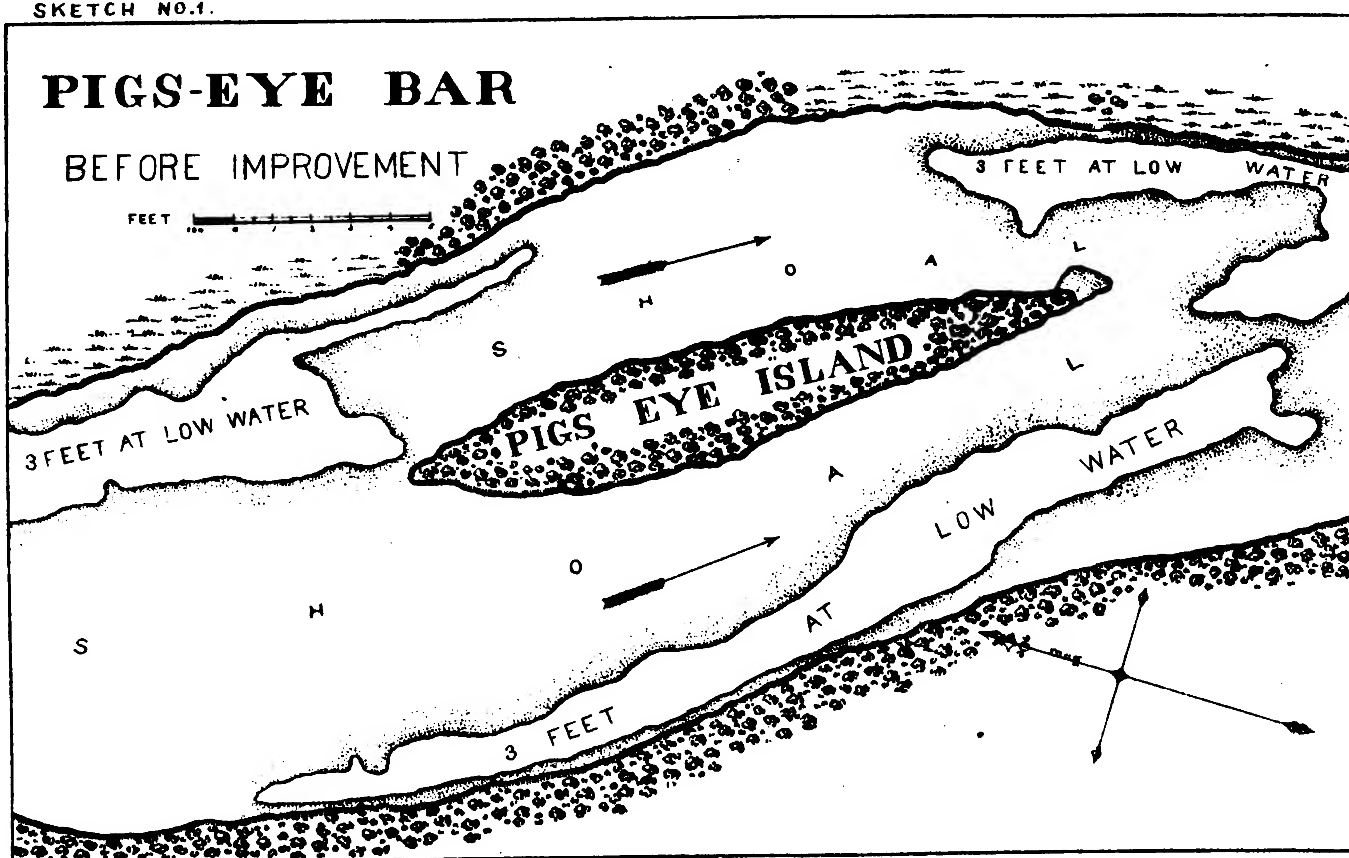
2. *Nininger Slough Bar.*—This bar, some 5 miles above Hastings, Minn., was, next to Pig's Eye, the worst bar on the river. Sketch No. 3 shows the situation in 1874. An island divides the river into two parts, and a portion of the north-channel water went down Nininger Slough. There was a very bad bar at the head of the island. Boats were often obliged to take the north chute, and, making an abrupt turn around the foot of the island, come back into the river through a very narrow passage, or *vice versa.* This route, in dark nights or windy weather, was very difficult and dangerous, and at all times troublesome. In 1875, (see sketch No. 4,) a loose stone dam (No. 1) was thrown across the chute from the head of the island to the northern shore; in 1876, it was found that the current in the passage at the foot of the island had become reversed, and was drawing considerable water from the channel into Nininger Slough; it was also gradually becoming wider. Accordingly, a dam (No. 2) was built across the outer end of the passage, and at present the entire body of water, at low stages, takes the main river. Sketch No. 4, from a survey made in 1876, shows the situation subsequent to the construction of the dams. The improved channel, of 3½ feet at low water of 1864, will afford from 4½ to 5 feet at ordinary low summer water, ample for all purposes of navigation.

3. *Minnesota Island Bar.*—Sketch No. 5 gives the results of a survey in 1875, prior to the building of the dam. At this locality, some 5 miles above La Crosse, the river is divided into two channels by various islands; of these, the eastern channel is called La Crosse Chute.

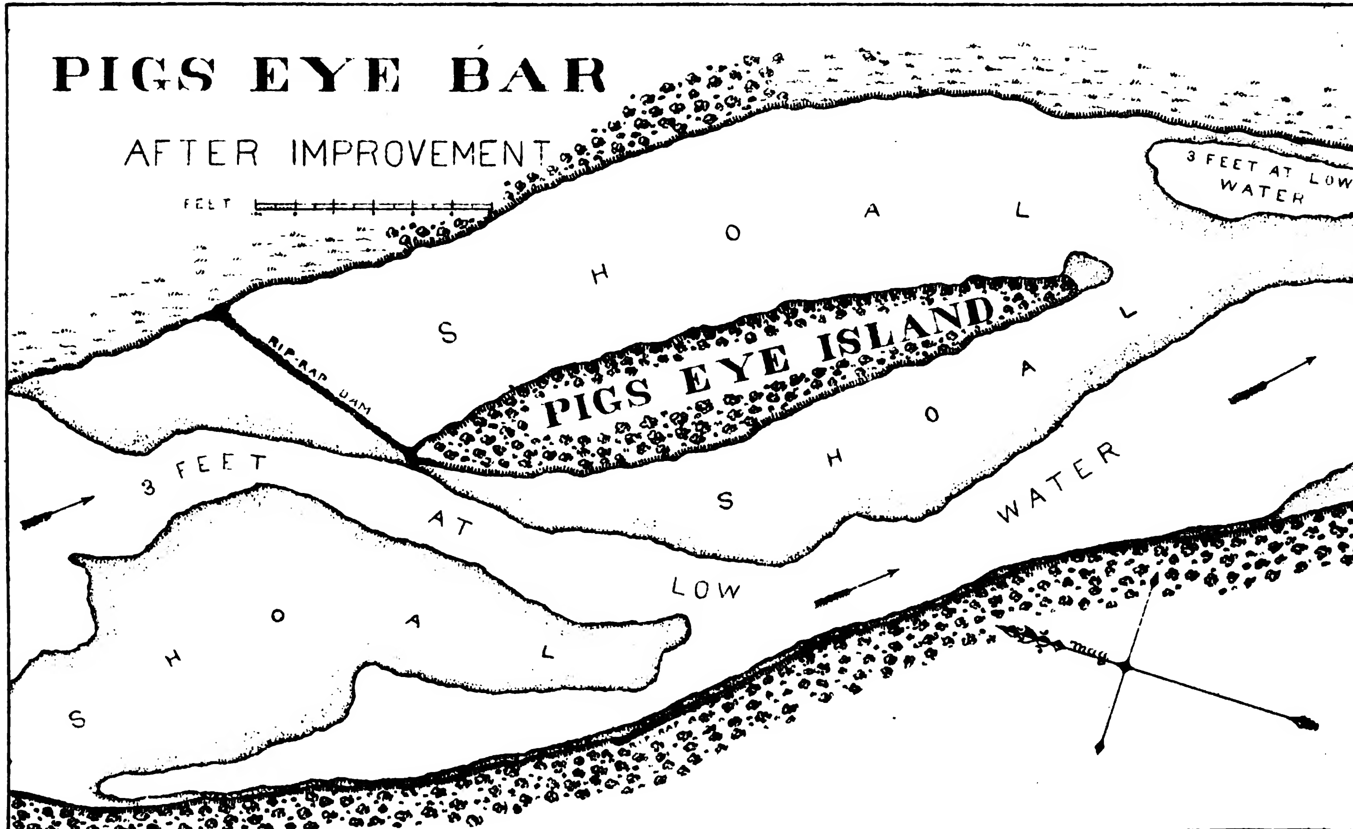
In former years sometimes one channel, and sometimes the other, was the main steamboat channel.

Sketch No. 5 shows deep water in La Crosse Chute; the difficulty, however, in this chute was caused by bars in the upper and lower ends, not shown in the sketch. There was also a very bad bar in the main river, at the head of Minnesota Island, and this bar was the chief obstruction to this channel. The Milwaukee and Saint Paul Railroad Company obtained authority from Congress to bridge the river at a point near the foot of Minnesota Island. They wished, however, to construct but one draw

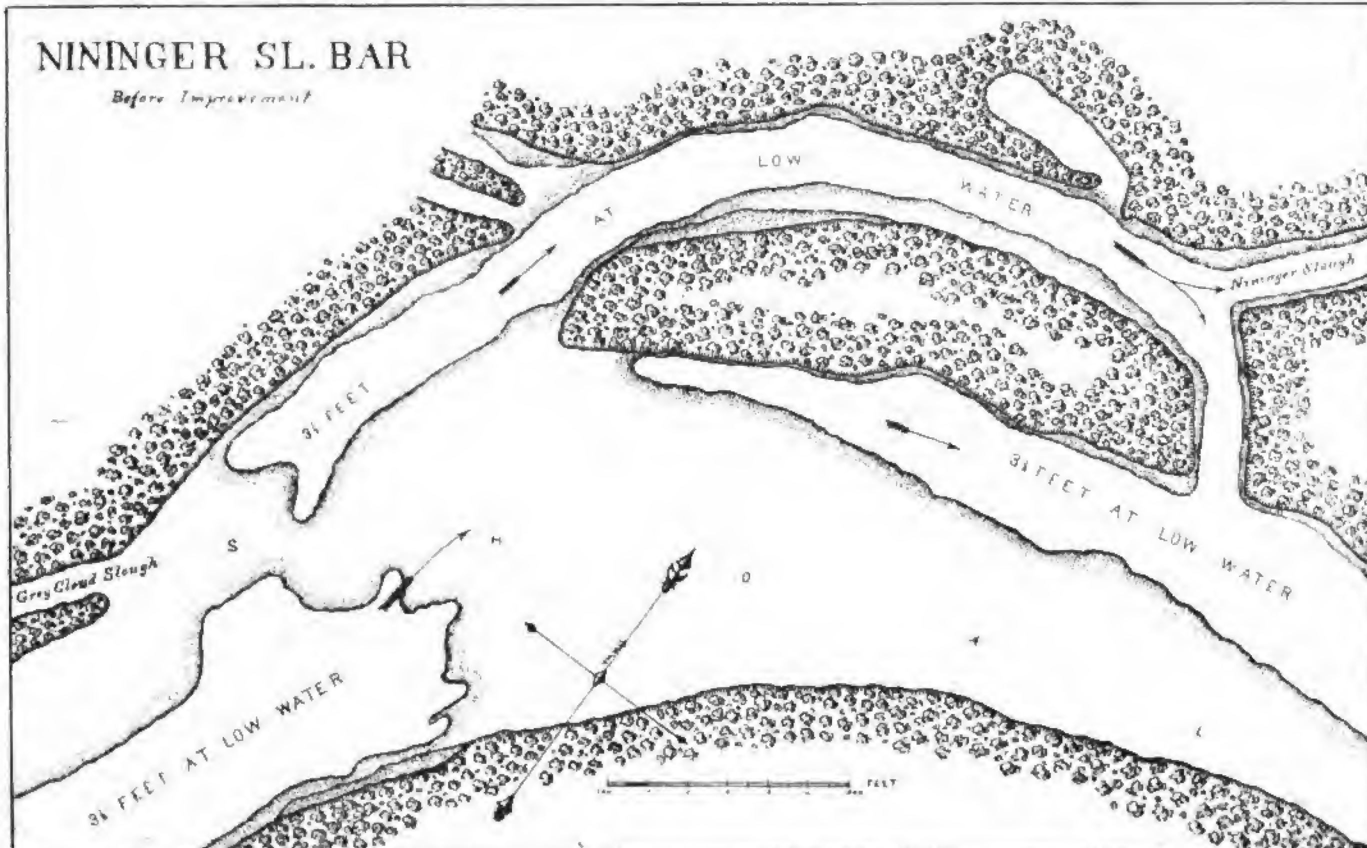
SKETCH NO.1.


PIGS-EYE BAR
BEFORE IMPROVEMENT
FEET
3 FEET AT LOW WATER
SHOAL
PIGS EYE ISLAND
3 FEET AT LOW WATER
SHOAL
3 FEET AT LOW WATER

SKETCH NO. 2

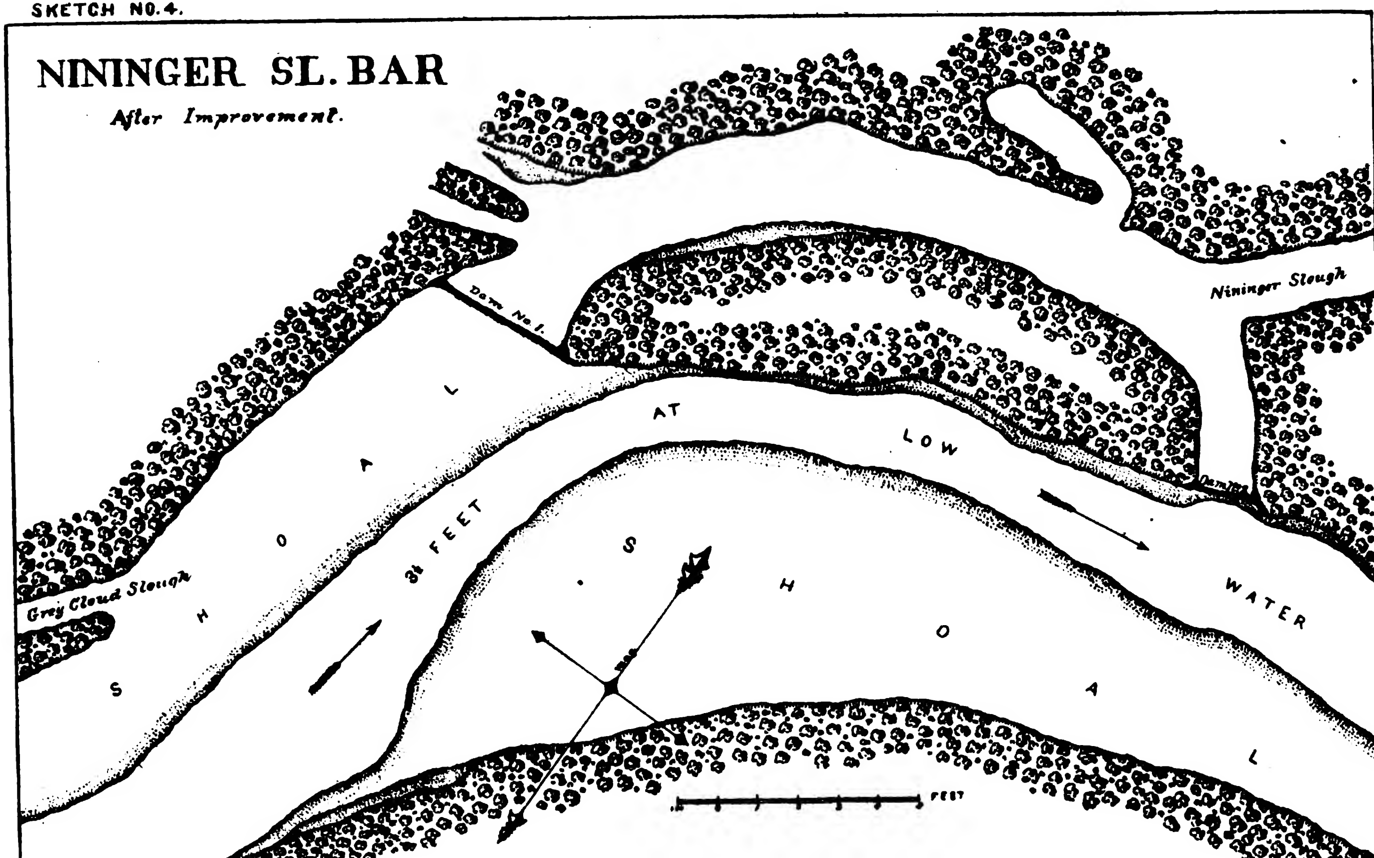

PIGS EYE BAR
AFTER IMPROVEMENT
FEET
RIP-RAP DAM
PIGS EYE ISLAND
SHOAL
SHOAL
SHOAL
3 FEET AT LOW WATER
3 FEET AT LOW WATER

SKETCH NO. 8.



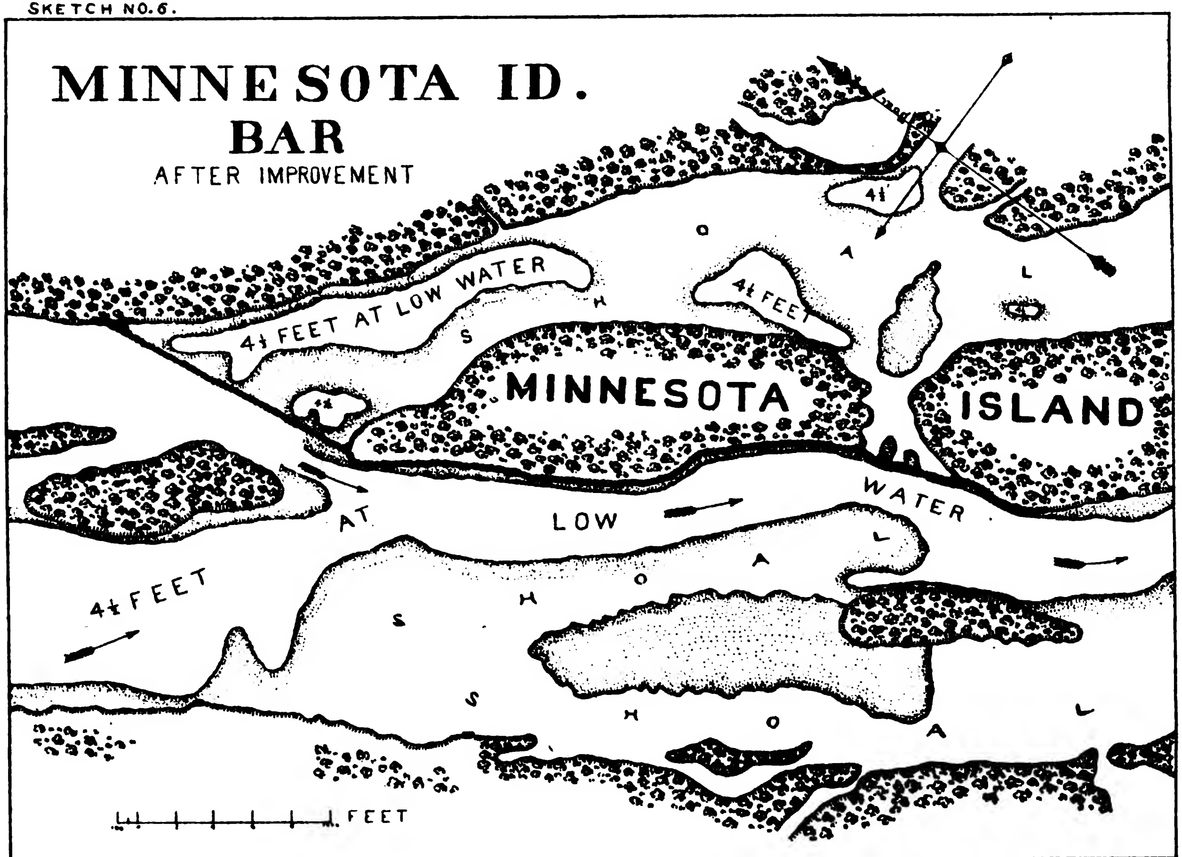
NININGER SL. BAR
Before Improvement
Grey Cloud Slough
Nininger Slough
3½ FEET
3½ FEET AT LOW WATER
AT LOW WATER
3½ FEET AT LOW WATER
FEET

SKETCH NO. 4.



NININGER SL. BAR
After Improvement.
Grey Cloud Slough
Dam No. 1.
Dam No. 2
Nininger Slough
SHOAL
3½ FEET AT LOW WATER
SHOAL
FEET

SKETCH NO. 6.



MINNESOTA ID.
BAR
AFTER IMPROVEMENT
4½ FEET AT LOW WATER
SHOAL
4½ FEET
4½
MINNESOTA
ISLAND
4½ FEET
AT LOW WATER
SHOAL
SHOAL
FEET

for the passage of boats, and were permitted to do this on condition of their closing up La Crosse Chute in such a manner as to remove the bar at head of Minnesota Island, and on fulfilling other conditions which it is not necessary to state here. Accordingly, under your directions, in the winter of 1875-'76, they threw a dam of piles, brush, and rock (see sketch No. 6) across La Crosse Chute, from the head of Minnesota Island to the eastern shore. They were also obliged to protect the western shore of Minnesota Island by riprap, and close up a narrow passage through the island.

A graphic illustration of the effects of the dam is given in sketch No. 6 from a survey made in 1876. It will be seen that a wide channel has been cut through the bar, and La Crosse Chute below the dam is rapidly filling up. There is now a wide channel in the main river of a minimum depth of 6 feet at ordinary low water.

The sketches were made by reductions from maps of accurate surveys, the soundings in great part located by triangulation.

I give below a list of bars above La Crosse, and the probable cost of permanent improvement, from surveys and estimates of M. Meigs, assistant engineer, and myself, under your directions, in 1874 and 1875. Should future improvements be made on a considerable scale, this part of the river would require immediate attention, as the bars are the most numerous and troublesome.

No estimate is given for the improvement of several bars, as the water was good at the time of survey. It often happens that some of the worst bars are, perhaps for a season or two, productive of no trouble, but the difficulties always return after some time has elapsed. Of course, then, if appropriations should be made for the permanent improvement of the river, the points of application should be left to the discretion of the engineer in charge, so that the improvement might be made at the worst bars for the time being.

Upper Mississippi River.—List of bars above La Crosse, Wisconsin.

No.	Designation.	Remarks.	Cost of dams.
1	Frenchman's	One mile below Saint Paul	$4,417 86
2	Pig's Eye	Improved in 1874	....
3	Kaposia	Often very bad	2,425 34
4	Upper Red Rock	.....do	3,140 04
5	Lower Red Rock	.....do	2,796 12
6	Newport	Two chutes	2,259 36
7	Merrimac	.....do	2,798 36
8	Robinson's Island	Very bad	3,414 20
9	Pine Bend	.....do	7,622 86
10	Gray Cloud	Sometimes bad	....
11	Boulanger's		2,307 44
12	Head Nininger Bluff	Improved in 1875 and 1876 under head of Nininger Slough Bar.	....
13	Nininger Bluff	.....do	....
14	Nininger	Bad cross'ng	6,399 40
15	Hastings	Channel narrow and shoal	2,850 08
16	Prescott Island	Two chutes	5,335 66
17	Diamond Bluff	Seldom bad	....
18	Waconta	Often bad	....
19	Below Read's Landing	.....do	....
20	Above Wabasha	.....do	....
21	Below Wabasha	.....do	....
22	Crats's Island	Two chutes, very bad	7,485 59
23	Beef Slough	Series of bad bars	12,747 23
24	Alma	.....do	15,130 94
25	Pine Island	Often bad	....
26	Above West Newton	Sometimes bad	....
27	Head West Newton Island	.....do	....
28	Minneiska	Often bad	....
29	Mount Vernon	Very bad	5,150 10
30	Chimney Rock	Very bad generally	....
31	Rolling Stone	Series of bad bars	12,706 06
32	Betsey's Slough	Two chutes	4,651 04
33	Wild's	Several chutes	3,845 50
34	Argo Island	Sometimes bad	....
35	Above Winona	Seldom bad	....
36	Elevator below Winona	.....do	....
37	Above Minneopa	Legendary	....
38	Below Homer	.....do	....
39	Mount Trempeleau	Several chutes	5,402 30
40	Below Trempeleau	.....do	....
41	Queen's Bluff	Sometimes bad	5,897 13
42	Below Dresback	Two chutes	5,309 04
43	Minnesota Island	Improved 1876	....
		Total cost of dams	124,092 75
		Add for shore-protections, engineering, contingencies, &c	75,907 25
		Grand total	200,000 00

This amount will, in my opinion, cover the entire expense of the permanent improvement of the bars estimated for, and but little annual outlay would be needed to keep the dams in repair.

APPROPRIATIONS.

There have been appropriated for improving Upper Mississippi River, under the various heads of "Repair, preservation," &c., "Snagboats and dredges," &c., and "Improving Upper Mississippi River," the following amounts:

By act approved March 2, 1867	$96,000 00
By deficiency bill of 1868	26,000 00
By act approved July 11, 1870	36,000 00
By act approved March 3, 1871	42,000 00
By act approved June 10, 1872	42,000 00
By act approved March 3, 1873	25,000 00
By act approved June 23, 1874	25,000 00
By act approved March 3, 1875	25,000 00
By act approved August 14, 1876	30,000 00
Total	347,000 00

The appropriations heretofore made from year to year have been sufficient only to keep the snag-boats in commission with a small crew during the low-water season. Experience has shown, during the past three years, that dams of loose rock are serviceable and permanent. In order to construct these properly, and at the least expense, a large force should be employed that the work may be done rapidly, thereby saving in material, for when the work is slowly done as it progresses the scour increases, and often at least twice as much rock is required as would be needed if the work were done with dispatch. If an appropriation of from $50,000 to $75,000 could be obtained, in addition to the usual allotment for the *Montana*, I firmly believe that from 5 to 10 of the worst bars could be improved in a single year. I would, accordingly, respectfully recommend for the fiscal year ending June 30, 1879, an appropriation of $75,000 for building dams at such points as may, in the judgment of the engineer in charge, be most expedient. This appropriation could be expended in the hire of additional men and purchase of flat-boats and tools, and the work might be done with the aid of the *Montana*, or, if preferred, by contract.

The *Montana* is now 13 years old, and it will require a heavy repair-account to keep her in a seaworthy condition after next season, and the expense will increase yearly. Her machinery is excellent, and could be used to good advantage in a new boat. The boilers would be unsuitable to transfer to another hull, and, consequently, I would respectfully recommend new steel boilers for a new steamer. In my opinion an iron hull to receive the *Montana's* machinery should be of about the following dimensions: Length on deck, 190 feet; beam, 37 feet; hold, 5¼ feet; full mold and transom stern. Such a hull, with the *Montana's* machinery and small cabin for the officers, should not exceed 24 inches draught.

The draught of the *Montana* is now 3 feet 3 inches, which is too much for effective work on the upper Mississippi during the low stages of the river.

Taking into consideration the age of the *Montana*, her heavy draught, and the large amount of money needed annually for repairs, it would in my opinion be expedient to build an iron-hull steamer to take the *Montana's* place. I give below an estimate of funds that could be profitably expended the fiscal year ending June 30, 1879.

ESTIMATE.

For permanent improvements by building dams at such localities as may, in the judgment of the engineer in charge, prove the most serious obstacles to navigation at the time the work is initiated		$75,000 00
For new iron steamer to take the place of the *Montana*, viz:		
New iron hull, including iron deck, deck-frame, boiler-deck, stanchions, and engine-timbers	$55,000 00	
Three steel boilers, complete	5,000 00	
Cabin, sheet-iron wheel-houses, and other upper work	5,000 00	
Transferring and setting up machinery, &c., in boat	1,500 00	
Total for iron boat		66,500 00
For current expenses of steamer Montana and working party for fiscal year ending June 30, 1879		25,000 00
Total		166,500 00

A permanent and thorough improvement is necessary to revive the freighting business of the upper river. Steamboats cannot successfully compete with the railroads along the banks during the low-water season, unless measures are taken to permanently remove obstructions to navigation, the vexatious delays and damage consequent upon which deter shippers and entail great expense upon steamboat-owners. Were the obstructions removed cheaper freights would result, and to the benefit of the States bordering upon and people interested in the navigation of the river.

STATISTICS OF COMMERCE AND NAVIGATION.

Lumber.

The most important business interest on the upper Mississippi River and its tributaries is the lumber-trade. The greater portion of the lumber comes from the pineries of Wisconsin, and is floated down into the Mississippi from the Saint Croix, Chippewa, Wisconsin, and Black rivers. A large amount is also manufactured at Minneapolis and the mills above, coming from the Mississippi above the Falls of Saint Anthony. In former years, before the construction of so many bridges, the lumber was floated independently of steamboats, but of late small steamers or tow-boats have been used to overcome the difficulties attending the passage of bridges, and at present nearly all the rafts are towed. There are about 100 raft-boats in the business.

The estimated total product of white pine floated into the Mississippi in 1876 is 1,350,000,000 feet, including logs, lumber, shingles, &c.

The amount of logs run into the Mississippi from the Saint Croix, Chippewa, and Black rivers in 1876 was about 515,000,000 feet. These logs went to supply the various mills on the river from Winona to Saint Louis, and the product was principally shipped west and east by rail from the various points of manufacture, a large amount, however, going to Saint Louis. In addition to the above, great quantities of lumber were manufactured on the Saint Croix, Chippewa, and Black rivers, and afterward floated into the Mississippi, and, being towed in that river for greater or less distances, finally shipped by rail to points of consumption.

The following table shows the amounts of lumber and shingles manufactured on the upper Mississippi River and its tributaries in 1876 and 1875, and affords a complete estimate of the lumber-trade. Most of the figures were obtained from the Lumberman's Gazette, published at Bay City, Mich.

Table showing lumber business of Upper Mississippi River and tributaries for 1876 *and* 1875.

Names, localities, &c.	Lumber cut in 1876.	Lumber cut in 1875.	Shingles cut in 1876.	Shingles cut in 1875.
Farnham & Lovejoy, O. C. Merriman & Co., W. D. Washburn, Minneapolis Lumber Company, and 26 other firms at Minneapolis	250,300,000	207,169,000	95,315,000	96,480,000
W. & J. Fleming, B. Stauer, and 6 other firms between Minneapolis, Minn., and Dubuque, Iowa	26,050,000	25,000,000	10,050,000	8,950,000
Dubuque Lumber Company, Ingram, Kennedy & Day, and 3 other firms at Dubuque, Iowa	20,400,000	14,000,000	10,050,000	11,000,000
W. J. Young & Co., C. Lamb & Sons, Lamb, Byng & Co., and 9 other firms at Clinton, Lyons, and Fulton	123,717,000	122,018,000	36,150,000	49,820,000
Weyerhaeuser & Denkman, Renwick, Shaw & Crassett, Keator & Co., and 9 other firms at Rock Island, Davenport, and Moline	104,350,000	74,550,000	26,814,000	27,364,000
Hershey Lumber Company, P. M. Musser & Co., S. & J. C. Atlee, Weston & Co., Tabor & Co., and 7 other firms below Davenport	91,400,000	87,375,000	58,925,000	63,235,000
Schulenberg, Boeckler & Co., Hersey, Bean & Brown, Isaac Staples, Seymour, Sabin & Co., and 8 other firms on the Saint Croix	66,793,000	75,520,000	30,195,000	51,525,000
Knapp, Stout & Co., Eau Claire Lumber Company, Union Lumbering Company, Daniel Shaw & Co., and 17 other firms on the Chippewa	255,866,999	264,077,000	79,250,000	72,500,000
La Crosse Lumber Company, C. S. Coleman, John Paul, P. S. Davidson, and 9 other firms on the Black River	70,852,747	62,000,000	27,475,000	27,800,000
Total for Mississippi River and tributaries, (125 firms)	1,009,729,746	931,709,000	374,224,000	408,674,000

The total sawing capacity of the mills of the firms above mentioned is 1,244,000,000 feet of lumber per season.

The receipts of lumber at Saint Louis in 1876 from the upper Mississippi River were:

	Feet.
White pine	112,786,133
White-pine logs	8,156,250
	Pieces.
Shingles	59,981,000
Lath	15,380,750
Pickets	6,803,000

Steamboats and freight.

The principal steamboat-lines on the upper Mississippi, above Saint Louis, are the Keokuk Northern Line, Capt. W. F. Davidson, president; and the Diamond Joe Line, Joseph Reynolds, president. Besides these, there are numerous independent boats carrying freight and passengers. The Keokuk Northern Line carried in 1876 118,501 tons of freight up stream, and 139,743 tons down stream; total amount, 258,244 tons. The Diamond Joe Line carried 93,676 tons of freight and 6,824 passengers.

The total amount of freight carried by both lines and the independent boats, including coal, ice, &c., aggregates about 586,896 tons.

In 1876 the arrivals of steamers from the upper Mississippi at Saint Louis were 908, with a tonnage of 376,820 tons.

In 1866 the arrivals were 917, with a tonnage of 377,804 tons.

The following table shows the amount of freight in tons received at and shipped from Saint Louis by the upper Mississippi River for 6 years:

	1876.	1875.	1874.	1873.	1872.	1871.
Received	224, 860	198, 100	231, 060	281, 175	242, 584	236, 887
Shipped	93, 360	96, 225	95, 800	61, 966	55, 235	78, 967
Total carried	318, 220	294, 325	326, 860	343, 141	297, 819	315, 854

Table showing the aggregate receipts in detail at Saint Louis from the Upper Mississippi River in 1876.

Articles.	Designation.	Quantity.	Articles.	Designation.	Quantity.
Apples	Barrels	45, 572	Hogs	Head	34, 904
Bacon	Pounds	1, 625, 502	Hops	Bales	44
Bagging	Pieces	54	Iron and steel	Bundles and pieces	3, 077
Barley	Sacks	145, 122	Do	Tons	306
Do	Bushels	38, 669	Lard	Pounds	365, [illegible]
Beans	Sacks and bushels	87	Leather	Rolls	1, [illegible]
Bran and ship-stuff	Sacks	3, 185	Malt	Sacks	1, [illegible]
Butter	Packages	3, 945	M'd'se and sundries	Packages	168, [illegible]
Cordage and rope	Coils	45	Do	Cars	9
Cattle	Head	11, 406	Molasses	Barrels	38
Castor-beans	Sacks	1	Oats	Sacks	272, [illegible]
Cement	Barrels	70	Do	Bushels	21, [illegible]
Cheese	Boxes	1, 881	Oils	Barrels	2, 377
Coffee	Sacks	53	Onions	Sacks and barrels	20, 190
Cooperage	Flour	2, 242	Pig-iron	Tons	10
Do	Pork	8, 622	Peltries—furs	Packages	3, 637
Do	Whisky	319	Pork	Barrels	13, 710
Do	Lard-tierces	17, 576	Do	Pounds	584, 579
Do	Lard-kegs	26	Potatoes	Sacks and barrels	43, 455
Do	Meat-casks	5, 345	Rye	Sacks	9, 214
Corn	Sacks	112, 532	Rice	Packages	15
Do	Bushels	24, 000	Seeds	Sacks and barrels	10, 619
Corn-meal	Barrels	4, 976	Sheep	Head	10, 357
Cranberries	Packages	1, 248	Staves	Thousands	13
Dried fruit	...do	426	Sugar	Barrels	35
Eggs	...do	2, 795	Tallow	Tierces and barrels	1, 555
Flaxseed	Sacks	872	Do	Packages	55
Flax tow	Bales	63	Tar and pitch	Barrels	249
Fish	Packages	2, 288	Tobacco	Hogsheads	2, 309
Flour	Barrels	51, 040	Do	Packages	33, 033
Grease	...do	595	Tea	Chests	15
High wines	...do	908	Wheat	Sacks	253, 173
Hay	Bales	72, 108	Do	Bushels	9, 000
Horses and mules	Head	3, 897	Wines and liquors	Barrels	948
Hemp	Bales	166	Do	Boxes and cases	750
Hides	Pounds	403, 501	Wools	Pounds	245, 225

The following table affords a comparative view of the relative amount of navigation at various localities on the Upper Mississippi, collated from the "Report of the Board of Engineers on Security of the Navigation of the Mississippi River," dated January 31, 1877.

Statement of steamers, barges, and rafts passing various bridges.

Locality of bridge.	Steamboats.		Barges.		Rafts.		Remarks.
	1875.	1876.	1875.	1876.	1875.	1876.	
Dubuque	2,771	....	776	......	1,136	......	
Clinton	2,471	....	600	.....	930	......	
Rock Island	1,830	1,976	630	696	618	627	
Keokuk	1,347	1,590	704	944	......	......	No record of rafts.
Quincy	....	2,320	......	650	......	283	
Hannibal	1,370	1,863	447	739	168	363	
Louisiana	1,496	*1,111	412	*472	109	*106	*1876, record only from January 1 to September 1.

CUSTOMS-REVENUE AND TONNAGE.

That portion of the Mississippi between Saint Paul and the mouth of the Illinois River lies partly in the customs-district of Minnesota and partly in the customs-district of New Orleans.

Surveyors of customs are located at Burlington and Dubuque, Iowa; Galena, Ill.; Saint Paul, Minn.; and La Crosse, Wis.

I include in the following statement the port of Saint Louis, where the greater portion of the Upper Mississippi boats are registered.

Customs-revenue and tonnage for the fiscal year ending June 30, 1876, Upper Mississippi River.

Port.	Collections.	Tonnage enrolled.	Remarks.
Saint Louis, Mo	$1,568,759 31	24,000	
Burlington, Iowa	214 75	454	8 vessels.
Dubuque, Iowa	1,137 35	3,307	38 vessels.
La Crosse, Wis	2,151 19	3,298	34 vessels.
Galena Ill	6,349 14	8,188	
Saint Paul, Minn	8,676 73	4,234	
Total	....	43,481	

INTERNAL REVENUE.

There are ten internal-revenue districts bordering on the Mississippi River between Saint Paul and the mouth of the Illinois. Each of these districts is composed of a large number of counties, the greater portion of which do not touch the river, but the bulk of the business receipts and revenue to the Government come from the sections bordering upon the river, and tributary to its navigation and commerce.

I give below a table showing the designation of the districts touching the river between the points above named, the residence of the collector, and the amount of collections for the fiscal year ending June 30, 1876.

District.	Residence of collector.	Amount collected year ending June 30, 1876.
1st Minnesota	Rochester	$87,444 24
2d Minnesota	Saint Paul	161,331 94
2d Wisconsin	Madison	155,278 72
6th Wisconsin	Sparta	91,302 80
2d Iowa	Davenport	181,898 45
3d Iowa	Dubuque	320,755 86
4th Iowa	Burlington	314,554 51
3d Illinois	Mount Carroll	1,299,832 96
4th Illinois	Quincy	1,469,504 47
4th Missouri	Louisiana	374,375 45
Aggregate	....	4,456,279 40

All of which is respectfully submitted.

Very respectfully, your most obedient servant,

C. W. DURHAM,
Assistant Engineer.

Col. J. N. MACOMB,
Corps of Engineers, U. S. A.

REPORT OF MR. M. MEIGS, UNITED STATES CIVIL ENGINEER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., June 30, 1877.

COLONEL: I have the honor to submit the following report on the works of improvement of the Upper Mississippi River.

I.—REPORT ON IMPROVEMENT OF THE UPPER MISSISSIPPI RIVER.

Assistant Engineer C. W. Durham's report contains the operations of the "Montana" to June 8, 1877, so I shall not need to refer to her movements prior to that time. During the winter the Montana lay on the ways at Kahlke & Brothers' ship-yard at Rock Island, Ill.

Under Mr. C. W. Durham's efficient and economical management and personal supervision the Montana was overhauled in the early summer of 1877, and such repairs made as were imperatively demanded. Her hog-chains were tightened and the whole boat straightened up, new timbers to replace broken and rotten ones were put in, and sundry necessary repairs made, so that she is now in a sufficiently seaworthy condition to last the rest of this season.

Much of the upper work of the Montana is very rotten—so much so that in high winds it is in danger of being demolished. During a gale last winter part of the texas-deck was raised up some 6 inches, stanchions drawn out, and a very near approach made to tearing off part of the forward end of the cabin.

The design of the Montana, built some thirteen years ago for a river packet-boat, is unsuitable for that of a dredge and snag boat. The machinery, though good, is expensive for fuel, and the remodeling of the whole steamer is demanded. I, therefore, heartily indorse Mr. C. W. Durham's report on the same subject, and approve of his estimate for rebuilding the steamer, which I recapitulate below.

On June 15 the Montana took her crew on board and raised steam for the first time this season.

June 16 to 19 the Montana made a cruise down the Mississippi River to Fort Madison, Iowa, pulling all the dangerous snags found, felling leaning trees, and cleaning up the shores generally.

At Fort Madison, Iowa, the Montana took Capt. R. R. Wallace, United States Navy, inspector fifteenth light-house district, and party on board, in order to assist them in distributing light-house supplies and locate new lights to assist in the difficult navigation of the river. The steamer Alice, belonging to the Light-House Department, being unable to cross the Keokuk rapids, it was deemed proper to thus offer assistance in locating these lights. In addition to assisting me in inspecting the sites of the proposed works at Fort Madison and Burlington Harbors, the Montana did much other service on this cruise, and several lights were placed by Captain Wallace below Rock Island.

June 20 the Montana left Rock Island for a cruise up the river, reaching Saint Paul June 29. On the way thither she removed many dangerous snags and leaning trees, and assisted in placing some 40 lights for the light-house service.

SUMMARY OF WORK DONE BY THE MONTANA JUNE 16–30, 1877.

Snags extracted	10
Leaning trees pulled back	24
Large leaning trees cut	251
Small leaning trees cut	1,743
Lights located	40
Soundings made	893
Miles run	722

ESTIMATE.

For rebuilding the Montana with new iron hull and steel boilers	$66,500
For current expenses of the Montana for the fiscal year ending June 30, 1879	25,000
For removal of obstacles to navigation and making permanent improvements	75,000
Total that can be profitably expended during the fiscal year ending June 30, 1879	166,500

II.—REPORT ON IMPROVEMENT OF THE HARBOR OF FORT MADISON, IOWA.

The original surveys and project for this work were made under your direction by Assistant Engineer C. W. Durham, (see Appendix T, Report Chief of Engineers, 1876,) and the cost of riprap and brush dams was estimated at $30,186.87.

An examination was made June 17 and 18, 1877, with the assistance of the Montana's boats and crew, of the bars opposite Fort Madison, and I find that there have been some changes in their position since the date of last survey, (1875.) The bars have moved somewhat lower down stream, but the same obstructions exist as formerly, and it seems as if more water were being drawn off by way of the Niota Chute, which it is proposed to close partially.

At low-water the same difficult crossings exist at the lower part of the town and below Fort Madison, and it is hoped the diversion of two-fifths more water into the main stream may have a very beneficial effect on these crossings.

The bids for furnishing stone for the riprap dam for this improvement were opened June 29, and the bid of Mr. Abraham M. Hutchinson, of Keokuk, Iowa, was found to be the lowest, at 82 cents per cubic yard, delivered within 1 mile of the site of proposed dam on the Illinois shore of the Mississippi River. I submit the following

ESTIMATE.

Original estimate	$30,186 87
Appropriated by river and harbor act, August 14, 1876	10,000 00
Amount needed to complete the work	20,186 87

III.—IMPROVEMENT OF RUSH CHUTE AND THE HARBOR OF BURLINGTON, IOWA.

The original surveys and plans for this work were made under your direction by Assistant Engineer C. W. Durham in August, 1875.

An examination of the Rush Chute made by me June 16, 1877, shows that the bar at the head of the chute has moved down some 200 feet during the last two years and now lies almost across the head of the chute, making navigation extremely difficult for rafts and steamers.

It would be a serious calamity to have the channel leave this chute, and the importance of the work for its protection is very apparent.

The appropriated amount of $10,000 will enable us to begin the improvement; but to make it permanent I respectfully submit the following

ESTIMATE.

Original estimate for improvement of Rush Chute and harbor of Burlington, Iowa	$35,221 70
Amount appropriated August 14, 1876	10,000 00
Balance needed to complete the improvement, and which can be profitably expended in the fiscal year ending June 30, 1879	25,221 70

IV.—REMOVAL OF A BAR IN THE MISSISSIPPI RIVER, OPPOSITE DUBUQUE, IOWA.

The original project for this work was also made by Assistant Engineer C. W. Durham. (See page 696, part I, Report of the Chief of Engineers for 1876, where the reasons for the improvement are sufficiently set forth.) Owing to local circumstances, the erection of a saw-mill on one of the cut-offs, and the insufficiency of the appropriation made August 14, 1876, I prepared a new project June 13, 1877, and submitted it to you. This project contemplates the removal of the sand-bar by dredging, in so far as the sum appropriated will allow, as this will give immediate relief to the navigation, now much cramped for space.

This project was approved by the Chief of Engineers June 20, 1877. The bids for this work will be opened at the latter end of July, 1877.

ESTIMATE.

44,584 cubic yards dredging, at 25 cents	$11,146 00
Cost of survey	1,000 00
Engineering and contingencies	2,854 00
Total	15,000 00

To complete this improvement and prevent the recurrence of this bar, I would suggest the construction of about 1,000 feet of training-wall, averaging, say, 11 feet in height and 35 feet base, from the upper point at New Barney Cut downward toward the railroad bridge, thus directing the current from New Barney Cut parallel with the main stream and preventing the formation of an eddy and the deposit of sand.

For this work I have the honor to submit the following

ESTIMATE.

20,000 cubic yards loose rock, at $1 per cubic yard	$20,000 00
Brush-work	3,000 00
Engineering, contingencies, &c	2,300 00
Total	25,300 00

V.—IMPROVEMENT OF THE MISSISSIPPI RIVER BETWEEN KEOKUK, IOWA, AND THE MOUTH OF THE ILLINOIS RIVER.

The Mississippi River below Keokuk as far as Alton, Ill., embraces many difficult shoals and crossings, which will become of the more importance now that the great canal at Keokuk is so near completion, and boats of all kinds, being no longer stopped by the Keokuk rapids, will be seeking employment on the upper river. The Light-House Department has organized and in working order an admirable system of lights, but to stimulate the steamboat trade on the Upper Mississippi a comprehensive system of improvements is needed, and before executing these, surveys are needed.

With the surveys made under your direction, (1874 and 1875,) under the call for surveys of transportation-routes to the seaboard, we have a very good knowledge of the present state of the river from Keokuk to Saint Paul. The great improvements at Rock Island, also, and at Keokuk, have had most admirable surveys made of them, but below Keokuk there is a blank, and to fill this blank I beg leave to submit the following estimate:

For building 1 quarter-boat and outfit complete	$3,000 00
Five months' hire of a small tow-boat, at $25 per day	3,750 00
Expenses of surveying-party, 5 months, at $1,500	7,500 00
Draughting, office expenses, &c	3,000 00
Total	17,250 00

Very respectfully, your obedient servant,

M. MEIGS,
United States Civil Engineer.

Col. J. N. MACOMB,
Corps of Engineers, U. S. A.

P 2.

IMPROVING DES MOINES RAPIDS, MISSISSIPPI RIVER.

The work for the present fiscal year was commenced under an allotment of $115,000 from the appropriation of $230,000 of August 14, 1876.

Operations were resumed September 13, and continued without special interruption until the close of the fiscal year. The balance of the appropriation, $115,000, became available April 11, 1877.

The work has been entirely confined to the canal proper, which is confidently expected to be available for the purpose of navigation by September 1, 1877.

The locks are all completed, with the exception of some little grading and macadamizing yet to be done.

The machinery for operating the lock-gates at the middle lock is entirely completed, and is in good working order. The machinery for the lower lock will be completed in a short time, and that for the guard-lock is well advanced. Substantial stone engine-houses and towers inclose the machinery at the locks.

The prism and embankment of the canal will be in condition to receive the water by the latter part of August or 1st of September.

Nothing was done upon the excavation of the channel above the canal between Nashville and Montrose. It is proposed to purchase a dredge

and remove the rock already excavated by chisels as soon as a dredge can be procured.

The original estimate for this work (report of Board of Engineers, dated July 20, 1867) was	$2,530,000 00
Total amount appropriated to date is	4,281,000 00

Under date of December 2, 1871, a Board of Engineers convened at Keokuk, Iowa, constituted by Special Orders No. 8, Headquarters Corps of Engineers, dated Washington, D. C., October 27, 1871, and in their report, published in Chief of Engineer's Report for 1872, gives details showing various reasons why the cost was very materially increased up to that date.

For the past four years the work has been mostly done by hired labor and the purchase of material in open market. This work has in almost all cases been completed within the estimates. Unfortunately, however, during the past two summers, and also the present up to this time, we have had a succession of violent storms, again and again flooding the entire work and greatly delaying and adding materially to its cost. Insufficient appropriations have also added greatly to the cost on account of damage to unfinished work.

Money statement.

Amount appropriated by act approved August 14, 1876		$230,000 00
July 1, 1877, amount expended during fiscal year	$106,830 97	
July 1, 1877, outstanding liabilities	17,518 73	
		124,349 70
July 1, 1877, amount available		105,650 30
Amount (estimated) required for completion of existing project		95,000 00
In addition to the above, the maintenance of the work for the fiscal year ending June 30, 1879, will require		40,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		135,000 00

REPORT OF CAPTAIN AMOS STICKNEY, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Keokuk, Iowa, June 30, 1877.

COLONEL: I have the honor to submit the following report of operations for the improvement of the Des Moines Rapids of the Mississippi River during the fiscal year ending June 30, 1877.

On the 1st of July, 1876, there were no funds on hand for the prosecution of this work, as the appropriation of the previous year had been exhausted.

The amount appropriated by act of Congress approved August 14, 1876, was $230,000, but this did not become immediately available. On the 15th of September, the sum of $115,000 was allotted to this improvement, and work was resumed. The remaining $115.000 was made available on April 11, 1877.

The original project submitted for the expenditure of this appropriation was to complete the work as far as possible, and included the following items, viz: Finishing construction of guard-lock; finishing lock and sluice-machinery, engine-houses, &c.; finishing lock-gates; building face of riprap wall on canal embankment; finishing rock-excavation in channel between Montrose and Nashville; removing cross-banks, &c.

Owing to the manner in which the appropriation was made available, it was decided to limit the work to such portions of the canal as were necessary to get it ready for use as soon as possible, leaving the rock-excavation in the channel above the canal until the last.

The canal, with locks, lock-machinery, &c., is now so far advanced, that I confidently look forward to the passage of boats some time in August or September, and the improvements already made in the channel above the canal are such as will, I think, allow boats to pass, if they are carefully handled.

No appropriation was made by Congress for the maintenance of this work during the

coming year, and, as the canal will probably be ready for navigation during the fall months, when it is most needed, I suppose it will be necessary to divert a portion of the construction-funds to that use.

The following is a detailed statement of the work on the various parts of the improvement, all of which has been done by hired labor.

SECTION-WORK.

On September 18 a small force was placed at work to repair the silt-dam at the mouth of Price's Creek, after which it was transferred to finishing the prism by the excavation of a small quantity of rock and some deposits from creeks that were above grade and located just below middle lock.

This work was continued until the 23d of December, when, on account of high-water and very cold weather, it had to be abandoned. The rock-excavation, about 400 yards, was finished, and a large portion of the deposit from the creeks was removed. During the year other deposits have formed, and a small force has been engaged removing the same, although considerably delayed by high-water and the severe rains of this season.

On account of the limited amount of funds on hand, the building of the riprap wall was suspended, and so remained until the reserve of the appropriation of August 14, 1876, became available, when active operations were resumed.

Wall-layers were started at every portion of the work where it was found practicable.

Stone was purchased and delivered at all available points, and the work pushed as rapidly as possible. With the exception of a few days' delay, caused by severe storms, the work has progressed unremittingly, with fair results. about 3,000 yards of wall having been laid and some 4,000 yards of stone purchased, a portion of which has not been placed yet.

The following is the present status of the section-work:

The upper level, from the guard lock to the middle lock, (with the exception of 600 feet opposite Price's Creek, and a little above, where the wall is only 4 feet above grade,) is in condition to receive the water now, and during the early part of the next fiscal year the lower level will also be ready.

Although the riprap protection-wall on the embankment as well as upon the shore-side is not completed, still it will soon be built to the 8-foot or high-water line, high enough to allow the canal to be used for navigation, and the balance can be finished more cheaply hereafter.

All of the regular excavation from the prism has been done, but there still remain two cross-banks and some bars, made by the deposit from creeks, to be removed before the water can enter.

The silt-dams at the mouths of the principal creeks emptying into the canal were partly washed out by a sudden storm, April 30, 1877, and numerous bars have been formed in the prism by washings from the adjacent bluffs, which would not have occurred had water been in the canal, and this material must be removed, or a large portion of it, before the improvement can be used for the purpose intended.

CHANNEL-EXCAVATION.

Very little has been done under this head during the last year. A portion of the Montrose coffer-dam was removed by the Keokuk Northern Line Packet Company, for their own convenience and at their own expense, and Government employés removed the balance at both ends of, not only the Montrose, but also the Nashville coffer-dam No. 2, enabling boats to use the channels as improved, over the upper chain and at the approach to the guard-lock. The chisel-boats and dredges were not used during the past year.

GUARD-LOCK.

On September 13, 1876, a force was placed at work to complete the guard-lock. There yet remained to be done the completion of the vertical wall connecting the lock-wall with the filling culverts, and the lower wing-wall to filling-culverts and slope-wal connecting with the riprap wall on the canal-embankment on the river-side; and the vertical and slope wall connecting the lock-walls with the shore-line of the canal, and completing the grading of the canal-embankment from the pier-head to the filling-culverts. This was all done by December 15, 1876.

Since the retained balance of the appropriation became available, work was commenced on the excavation of the earth and rock in the prism of the canal in the guard-lock section, immediately below the lock, which was finished June 28, and now all the guard-lock is completed with the exception of a small amount of slope-wall to complete the lower inside connections with the shore-line of the canal, the shore and riprap walls connecting with the dike on the upper end, the grading and finishing the grounds about the guard-lock, all of which is not now necessary to operate the canal, and can be done at any convenient season of the year or await a future appropriation.

ENGINE-HOUSES.

In connection with the completion of the guard-lock, there was employed a force or stone-cutters, with the necessary laborers to assist them, who were engaged at cutting stone for building the lower-lock engine-house. After the stone was dressed it was transported by railroad to the lower lock, where the masons were erecting the building.

This engine-house corresponds precisely with the plan of that erected at the middle lock in 1875. These buildings are put up in the most durable and substantial manner, the stone all specially selected from the magnesian-limestone quarry at Sonora, Ill., and all carefully and neatly dressed, and laid in hydraulic-cement morter. The partitions and flue above the foundation are of the best quality of hard brick, manufactured at Quincy, Ill.

The foundations of the building and the engine and boiler bed rest upon the solid rock. These buildings are made to contain the machinery that is used in operating the lock-gates. Two of these buildings are now completed, and the one for guard-lock not begun.

LOCK-GATES.

The construction of the lock-gates has received the most particular attention. The necessary labor was employed, and the work begun soon after the funds became avilable.

First, at the middle lock. The completion of the middle-lock gates only required the putting in of the suspension rods in the two upper gates, some of the wicket jambs, and the decking. The gates are decked with white-oak plank, 3 inches thick by 12 inches wide, closely matched together; the edge of each plank is grooved to receive a 1-inch by a ¾-inch tongue in each joint in the decking, made of perfectly dry pine, and wherever there was any possibility of leaking, it has been well calked with oakum.

On the upper gates at the middle and lower locks the decking is placed on the upper side of the two lower arch timbers, and above them it is placed on the upper side of the straight timbers.

The decking is placed in like manner on all the gates, only on the lower gate at the lower lock the change from the arch to the straight timber is made on the fifth timber from the top, and on the lower gates at the middle lock and all the gates at the guard-lock it is made on the fourth timber from the top. This transfer is made to add additional water-weight to the gates to prevent the upward pressure on the bottom of the gates from lifting them when a full head of water is on the upper side.

As soon as an engine and pump could be got ready, the lower lock was pumped out, and work was resumed on the gates. The water was all out by October 5, when the lock was found to contain about 3 feet of soft mud, which was the cause of considerable annoyance.

The work on the gates was stopped from December 15 to January 12, and from February 15 to the 22d, on account of the lock-chamber being flooded by overflows of the guard-bank, caused by ice-gorges in the river below.

We were finally able to complete all the work necessary to be done below ordinary water-line before the spring rise of the river, and the work then proceeded without interruption.

The wood-work on the middle and lower lock-gates has received three coats of paint, and all the wrought and cast iron two coats of mineral paint.

The gates of the middle and lower locks were completed by March 20, and the force transferred to the guard-lock to construct those gates. The material was already delivered, the most of it having been procured during the previous year, but for want of means we were not able to properly care for the timber, and it had seasoned quite hard, and was badly out of shape, which made it a difficult matter to work it, and greatly increased the labor of dressing and preparing. Very fair progress has been made in the construction of these gates.

The upper ones are completed. The two lower ones are built and suspended, and one of them about half decked, and the wickets are in the same. All of the painting yet remains to be done.

I had hoped to be able to report them completed at the end of this year, but the work was attended with an extra amount of labor, and there was some delay in receiving the oak timber necessary to complete them. This is now all on hand, and these gates will soon be finished.

The stems and levers for operating the wickets in all of the gates, except the two lower gates of the lower lock, are yet to be put on.

LOCK-MACHINERY, ETC.

On September 12 Messrs. Sample, McElroy & Co. were directed to resume the construction of castings and the necessary fitting up of same.

On September 13 a foreman and gang of laborers commenced the work of cleaning and painting the machinery which had been erected at the middle lock. A great deal of work was required to remove rust and thoroughly oil the pulleys, guide and piston rods, and other parts of the machinery which had been partially exposed to the weather during a period of nearly six months.

It was also found that a mass of drift-wood had collected and matted together in front of the sluice-openings in such a way as to greatly obstruct the flow of water through the sluice, which caused an overflow of the upper level that deposited logs and drift-wood in the upper recess and about the culverts and gates. All this drift-wood was removed from the sluice, the cross-banks at upper and lower ends of the lock repaired and raised, and a pumping-engine having been placed in position, the pumping out of the lock was commenced September 23.

The upper east-side cylinders, which had been only partially set, were taken up and carefully reset; the excavation for upper west-side cylinders was completed, and the inclosing stone walls for both sides built up as rapidly as possible, in order to finish all stone-laying before the inclement weather of winter should cause a cessation of work.

The upper west-side cylinders were set and pipe-connections made with the distributing-valve in engine-house.

The cut-stone bases which support the machinery above the coping were built, and the iron beams and covering-plates set, and securely anchored down by heavy wrought-iron straps bolted to the lower courses of lock wall. All the pulleys were placed in position and bolted, and the connections for chain-cables and wire-rope completed; all the pulleys on the lock-gates were adjusted, and the guiding-blocks which keep in position the chain-cables used in opening the gates at lower recess were adjusted carefully and firmly bolted down to the solid bed-rock, being also backed up by stone. After careful experiment, it was deemed best to substitute cylinders 16 inches diameter for the 9-inch cylinders at first designed to operate the lower gates. This was accordingly done, and, although a tedious job, requiring great care and close work in a contracted space, the change was satisfactorily accomplished, and the 9-inch cylinders taken out were removed to the lower lock, where they were afterward used for the upper gates. Covering-plates and anchor-straps, which were at first omitted, have been placed over the stone bases at lower recesses.

At the upper recesses cast-iron guiding-circles, supported by columns which are bolted to the solid bed-rock, keep in position the chain-cables which open and shut the lock-gates.

These guiding-circles are made in segments, which are accurately fitted together, so that they receive the same character of strain as that placed upon a perfect arch; the end segments are bolted respectively to the miter-sill and recess-wall to prevent displacement. By this method of taking the pull, great strength and lightness are combined, and an uninterrupted flow of water to the culvert-gates is insured. The iron columns and top plate to secure guide-rods, and the inclines on which the movable sheaves roll, have all been placed in position, both at upper and lower recesses.

One iron tower for inclosing the machinery, which is supported by the stone bases, has been constructed, but it was deemed best to substitute wood for iron on account of the great saving thereby effected, both in cost of material and labor of construction. The three remaining towers at this lock were accordingly built of ¾-inch pine flooring, tongued and grooved together, with braces sufficiently close to prevent warping of the boards, and each side is so made as to admit of its removal entire, without disturbing any other part of the structure.

All the towers have been painted in three coats externally and two coats internally, the wooden towers being carefully sanded with coarse flint sand as a protection against fire, and to deter mischievous persons from cutting the wood-work; the roofs are covered with tin, and provided with ventilators for carrying off the moisture which constantly arises from the cylinders; doors and windows give entrance to the tower, and furnish abundance of light.

In the engine-houses the doors and window-sashes have been placed in position, and all the wood-work painted in three coats. A water-tank with a capacity of about 260 gallons has been constructed in the attic for supplying the boiler-pump, and for general use.

Some minor changes have been made in the distributing-valve and the machinery for operating the same.

The machinery for operating culvert and lock-gates has been subjected to severe tests, from time to time, and found to work satisfactorily, leaving a large surplus of pressure, which can be drawn upon for extraordinary occasions.

The work at the lower lock, which was resumed in the fall of 1876, is of similar character to that which has been minutely described in former reports of the middle lock.

The culvert and sluice-gate frames, culvert-gates, gate-stems, wall-brackets, pulleys, cylinders, and plates, have all been adjusted and permanently secured. All the stone bases for machinery and the wooden towers inclosing machinery are finished.

The wire-rope and chain-cable connections have been made, and the water-pipes carried into engine-house, where the distributing-valves are only needed to form the connecting-link between the hydraulic cylinders and pumping-engine.

The hydraulic cylinders used at this lock are of the following sizes: For upper and lower culverts, 16 inches diameter; for upper lock-gates, 9 inches diameter; for lower lock-gates, 16 inches diameter.

The pumping-engine and boiler are of same capacity as those at middle lock; some changes in the steam-valve and valve-gear of engine have been made.

The pumping-apparatus has been tested, and found to be in good working order.

The wood-work of engine-house is of similar design to that at the middle lock, with the addition of a dormer window on the roof for light and ventilation of the attic, and the floor-joists are of white pine instead of Georgia hard pine.

All the work has been carefully executed, and is of a character to endure for many years.

The roof is covered with tongued and grooved pine flooring, felting, and best quality Lehigh slate, copper gutters, and galvanized-iron hippings and water-pipes.

All wood-work inside and outside of engine-house painted in three coats.

During the prosecution of this work, frequent delays were caused by sudden rises in the river about the time of the breaking up of the ice in the spring. Constant watchfulness was required to prevent the destruction of the cross-banks, and consequent flooding of the lock. It was found necessary to keep the men at work after regular hours, and, while the guiding segments were being secured, they were obliged to work Sundays as well.

At the guard-lock the culvert-gates, gate-stems, and wall-brackets are secured in position. The work of adjusting the guiding-circles is nearly completed, and the bottom pulleys secured to gates. Workmen are now employed in setting pulleys, and blocking for same, on top of gates.

The necessary castings for the construction of machinery at this lock are now being prepared.

The window-frames and sashes, doors and door-frames, and other parts of the wood-work for engine-house are being constructed to insure against delay.

The summary of work performed on machinery includes the completion of machinery, and appurtenances thereto, at middle lock.

The completion of machinery at lower lock, (with the exception of the distributing-valve,) considerable progress toward the erection of machinery at guard-lock, the completion of the wood-work for engine-house at middle and lower locks, and some preparation of window and door fittings for engine-house at guard-lock.

Taking into consideration the fact that for little over nine months of the fiscal year were men employed in a prosecution of this work, and at least half of that time being during the stormy season of the year, good progress has been made toward final completion.

The gentlemen who have assisted me in the supervision of this work have performed their duties with zeal and efficiency.

I remain, very respectfully, your obedient servant,

AMOS STICKNEY,
Captain of Engineers and Brevet Major, U. S. A.

Col. J. N. MACOMB,
Corps of Engineers, U. S. A.

P 3.

IMPROVING ROCK ISLAND RAPIDS, MISSISSIPPI RIVER.

The work of excavation at lower chain was closed by a final estimate after inspection with the rake of the sounding-machine had proved the satisfactory accomplishment of the removal of the *débris* of coffer-dam and cribs. Congress appropriated $25,000 for the prosecution of the work of improving these rapids August 14, 1876, but only $10,000 were allotted by presidential direction to be expended for the present.

Your letter of September 15, 1876, apprised me of this fact, and directed me to submit a project for the expenditure of this sum at these rapids. I stated that the closing work at these improvements consists in removing 2,505 cubic yards of rock at the foot of Moline Chain, and that the

allotted sum could most judiciously be applied in commencing the work of excavation by means of chisel right away, because each single cubic yard disposed of at that place would benefit navigation. I proposed further to be allowed to prosecute the work by hired labor and machinery, as being the cheapest. You approved this project under date September 29, 1876, and after the necessary arrangement the chisel-boat was placed in position at Moline Chain on the middle of October, and was worked there till the running ice induced me to stop the work November 28, 1876. During that fall 103.5 cubic yards of rock were broken by the chisel.

Under date April 19, 1877, the allotment of $15,000, the remainder of the appropriation of $25,000, was made for the prosecution of the work, and my project of continuing the work at Moline Chain by hired labor and machinery approved. I preferred to hire the chisel boat and have the crew engaged under the supervision of an assistant engineer, instead of hiring a manned chisel-boat of the contractor, and pay by the day or hour. On the 8th of June the chisel-boat was at work at Moline Chain, and a good result has been obtained by this arrangement. During the month of June 143.3 cubic yards of rock were broken, a result exceeding the work of last fall about 42 per cent. I expect to dispose of 750 cubic yards during the season.

Of the 2,505.8 cubic yards on Moline Chain, there are then still 1,655 cubic yards of rock to be broken by the chisel, and 2,505.8 cubic yards to be removed by the dredge. For this closing work a sum of $30,000 is needed. Besides this work there should be made a thorough survey by sounding-machine and attached rake at the different cuts and improved channel for ascertaining if bowlders or detached pieces of rock have been brought into the channel by the ice. For the removing of such pieces of rock or obstructions, further for the mentioned survey, and the erection of guides or landmarks on shore, or bouys, and the publishing of a lithographed map for the information of the navigators, including all engineering expenses and contingencies, a sum of $20,000 will be the minimum, so that I am fully justified in asking a final appropriation of $50,000 for closing the work of improving the Rock Island Rapids during the fiscal year closing June 30, 1879. I most earnestly recommend this final work of closing the Rock Island improvement to the consideration of Congress, and most urgently request that the full sum of $50,000 may be given, so as not to draw the final closing of the work into another fiscal year. The improving of the Rapids has been so far a success.

For further information, in detail, in regard to operations during the fiscal year ending June 30, 1877, I beg leave to refer you to the report of Assistant Engineer E. F. Hoffman, which is herewith submitted.

Money statement.

July 1, 1876, amount available	$5,729 16
Amount appropriated by act approved August 14, 1876	25,000 00
	30,729 16
July 1, 1877, amount expended during fiscal year	15,966 29
July 1, 1877, amount available	14,762 87
Amount (estimated) required for completion of existing project	50,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	50,000 00

REPORT OF MR. E. F. HOFFMANN, ASSISTANT ENGINEER.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., July 2, 1877.

COLONEL: I have the honor to submit my annual report of operations for the improvement of the Rock Island rapids of the Mississippi River during the fiscal year ending June 30, 1877.

I stated in my last annual report that the final estimate in regard to the excavation of rock at lower chain could not be presented because the unusually long high-water stage had prevented an inspection with the rake of the sounding-machine. On the 26th of July, 1876, the surface of the water read 4 feet above low water of 1864, and the inspection was undertaken at once. In moving with the rake of the sounding-machine over the area where the coffer-dam stood, large remains of the same were found; also remains of stone cribs which had guarded the coffer-dam. The contractor was informed that no final payment on the work of excavation at lower chain could be made until the *débris* of coffer-dam and cribs were properly removed, and he was invited to commence the dredging at once.

From the 27th of July to the 8th of August the dredge was employed in accomplishing the work of removing the *débris*, and when at that last-named day the rake of the sounding-machine went over the area in question, the work of removal proved to be satisfactorily done, and payment of the 10 per cent. retained was made, and the contract at lower chain, with George Williams, contractor, virtually closed by it. Here follows a copy of the final estimate:

Final estimate of work done by George Williams under his contract for improving Rock Island rapids of the Mississippi River, commencing October 7, 1875, and ending August 8, 1876.

Items.	Quantities.	Contract price.	Amounts.	Percentage retained.	Amount of payment.
Total amount of work done.	*Cub. yds.*				
Rock excavation and removing at lower chain	2,340.5	$12 00	$28,086 00	$2,808 60	$25,277 40
Total amount of work done including retained percentage			28,086 00		
Deduct former payments as per receipted vouchers			25,277 40		
Balance due, (retained percentage)			2,808 60		

GEO. WILLIAMS.

J. N. MACOMB, *Colonel of Engineers, U. S. A.*

Congress appropriated by an act August 14, 1876, the sum of $25,000 for the work of improving the Rock Island rapids of the Mississippi River, but only $10,000 of this appropriation were allotted by order of the President to the Rock Island rapids for the fiscal year ending June, 1877, of which fact you were apprised by letter of the Chief of Engineers, United States Army, dated September 15, 1876, and directed to submit a project for the prosecution of the work at these rapids. As from this sum of $10,000 the amount of $2,000 was paid to Attorney-at-law Mr. J. Schroder, of Cincinnati, for services of conducting the defense for the United States in certain claim cases, for which authority was given by the Secretary of War in a letter from the Chief of Engineers, dated September 2, 1876, the real available sum for the work of these rapids was reduced consequently to $8,000 during the fiscal year. It was thought prudent to commence the work of excavation at the foot of Moline chain, which work in my last report was alluded to as the closing stone to the improving of these rapids. The reason for recommending this work was, that with the small appropriation only a limited amount of rock could be excavated, but that this limited amount of excavated rock would here at the foot of Moline chain do the greatest benefit to navigation. The work of excavation at the foot of Moline chain consists in removing patches lying more or less in the midship of the channel in which a current of water flows, exceeding in some places 8 feet velocity per second.

Coffer-damming a smaller or larger place on this chain would practically close navigation, and is therefore beyond consideration; even if with excessive costs the constructing of such a coffer-dam was desired, there remained but the means of using chisel and dredge for the removal of the 2,505.8 cubic yards at the foot of this chain. I respectfully invite your attention to the small map of Moline chain herewith inclosed. Experience has shown that bids for removing rock by means of chisel and dredge have reached

as high as $18 and $20 per cubic yard on other chains, and it was therefore expect that bids at the Moline chain would leave these indicated prices far behind. It w thought, therefore, advisable to hire a chisel-boat by the hour or day and bind the co tractor by an agreement in reference to the time and manner by which the work of t chisel-boat was to be regulated and controlled by the engineer assistant in the fie Your project in relation to the work at Moline chain was approved by the Chief Engineers, United States Army, under date September 29, 1876, and an agreement ma very soon with Mr. George Williams, of Keokuk, in reference to the hire of a chis boat. On the 16th of October the boat arrived from Keokuk and was brought in position at Moline chain. The next day a raft collided with the chisel-boat, broke t spud, and took the boat considerably down stream.

Time was lost by the contractor in repairing the breakage and in sending fo steamer, which proved to be indispensable for handling the chisel-boat in the str current of Moline chain. The chisel-boat sprung a leak, besides, and had to be paired, which again caused a delay of several days, so that little was only accomplis during the month of October, 1876. During the month of November the chisel-b work was carried on steadily until the 28th of November, 1876, when some parts of machinery of the boat got out of order, and heavy frost setting in you were indu to stop the work of excavation. The chisel-boat worked over a surface of 2,542 squ feet, the average cutting of the rock was 1.1 of a foot, and consequently an amount 2,796.2 cubic feet or 103.5 cubic yards of rock was chiseled during that time. this work $1,168.75 were paid. When compensation for the work of removing chiseled rock by means of a dredge is added to the amount of $1,168.75, which w will require the employment of a dredge for the period of three days, and the u rent of $100 is considered, then the removal of the 103.5 cubic yards of rock at Mol chain at the mentioned patch A (see sketch) would cost the Government as follow

Chisel-work	$1,16
Dredge-work	30
Total	1,46

Or per cubic yard $14 by the system of hiring boats and machinery. As I al stated that bids at a public letting would have reached $18 or $20 and more, it is dent that the Government has been benefited in the system of hired labor and chinery. Before the work with the chisel-boat commenced, you charged me in month of September to proceed with some of the assistants to La Crosse, Wis., for purpose of making a survey at the site near the railroad-bridge of the Chicago, waukee and Saint Paul Railroad Company over the Mississippi River, then about be constructed. Petitions were some time ago submitted to the Secretary of War cla ing the bridge in erection to be and become a hinderance to navigation. The mat was referred to you for report, and you ordered especially observations of directio current above the bridge, and the defining of the sand-bars by a horizontal curve- 4 feet below low water of 1864. As the sand-bars were found to be changing and sh ing daily, you directed me to make another survey at the same place two months la for enabling you to judge better the merits of the petition in question. Both surv were plotted on one and the same map, and by the 1st of January this work as wel the working up of field-notes during the work with the chisel-boat were accomplis

The smallness of the allotted amount of money made it imperative to part with services of one engineer assistant and draughtsmen, and they were discharged other funds would be available.

In the spring of 1877 you directed me to prepare a project for the continuatio rock excavation at these rapids, under the view that the $15,000 still remaining the Treasury would be made sooner or later available. Under date of April 6 I sta in my report to you that, in view of the smallness of the amount of money for work on these rapids, and the necessity of doing the same by chisel and dredge, which contractors have always charged a very high price,) and in view of the pecu difficulties arising from the very strong current and exposure to frequent interrupti by passing steamers and rafts, it would be out of question to expect other tha very high bid from any contractor conversant with such work; and the interrupti alluded to would doubtless lead to claims for damages, &c. For these reasons I reco mended that the work of excavation might be done by hired labor and machine and that the work of excavation might be continued right at the patch A, (see ma on which last year the work was stopped on the last day of November.

You approved of my project, and you submitted, under date of April 6, 1877, a le to the Chief of Engineers, requesting authority to do the work at Moline chain hired labor and machinery instead of letting the work. The Chief of Engineers, i letter dated April 19, 1877, informed you that the Secretary of War, upon the rec mendation of the Chief of Engineers, had authorized the expenditure of the unallo balance of $15,000 for the improvement of the Rock Island rapids of the Mississi

and approved of your recommended project to do the work of excavation by hired labor and machinery.

You directed me to make the necessary arrangements for the prosecution of the work of excavation, in consequence of which I proceeded to Keokuk, Iowa, for the purpose of hiring a chisel-boat from Mr. George Williams, of Keokuk.

An agreement was drawn up, approved by you, according to which Mr. Williams should put a certain chisel-boat in quite a seaworthy condition; have the whole machinery thoroughly repaired and overhauled; to provide the boat with a new part of machinery, which was to serve to tow the boat in the heaviest current with a suitable velocity, and thus dispensing with the service of a steamer; to furnish certain machine parts in duplicate and triplicate, and provide the boat besides with a prescribed amount of rope, anchors, &c. In consideration of this, you agreed to hire the chisel-boat for a term of five or six months, and stipulated the price for the hire of the boat to be $300 per month, or $20 per day. In case the stage of the water in the river would be 5 feet and more than 8 feet above low water of 1864, the price for the hire of the boat had to be reduced to $10 per day, as less work, or no work at all, could be effected during such a high stage of water.

The repairs on the designated chisel-boat were commenced soon afterwards, and the progress and the thoroughness of the repairs and alterations of the machine parts was daily inspected by me. On the 1st of June the boat was in good working capacity, steam was got up, and you, colonel, visited yourself the chisel-boat, examined it, and authorized me to take charge of the boat and to commence actual work of excavation as soon as practicable. A very high wind detained the towing of the boat to Moline chain till the 4th of June, on which day it was brought into position at the foot of Moline chain. The boat is manned by a chisel-tender, engineer, fireman, and watchman, and the coals are delivered on a flatboat to the boat for the price of 10 cents per bushel.

On the 5th of June a raft of 11 strings had become disengaged from the pushing steamer, some parts of the machinery of the steamer having got out of order above Duck Creek chain; the helpless raft floated down, collided with the right corner of the chisel-boat, broke the spud and carried the boat more than half a mile down stream, where it got free, and was held by an anchor thrown out. On the 6th of June, the part of the new-built machinery showed its effectiveness by pulling the boat, by means of thrown-out anchors, back to the place in about two hours. As the spud had to be inserted anew the boat was brought to the shore of Benham's Island, just opposite the place of work, and the repairs commenced at once.

On the 8th of June the boat was in her position at patch A again; actual work of hammering with the chisel was commenced, and has, since this time, been carried on with good effect. The crew of the boat being fresh men, they received orders to commence by dropping the chisel not more than two times per minute, till everybody was familiar and at home with the business to be performed. In a time of five days the men were so drilled that three blows and since the last ten days four blows with the chisel are struck per minute, in the average, a result which speaks very well for the competency and faithfulness of the crew. I cannot leave unsaid that the work at this chain is full of danger for the crew. The handling of ropes and anchors in the very heavy current must be done with utmost care; even the communication by skiff closely between the boat and the shore, especially the landing, must be watched, or capsizing and endangering the life of men is the consequence. During the month of June, 3,870 cubic feet or 143.3 cubic yards of rock were brokenby the chisel.

The chisel-boat last fall left off work under the following data in reference to ordinate and absciss of the base line laid down upon the hydrographic map of Moline chain: November 28, ordinate 593.4, absciss 417.8; the boat commenced work under June 8, ordinate 598.7, absciss 417.5, and on June 30, ordinate 621.3, absciss 477.7.

From the above abscisses it will be seen that the chisel-boat was 60 feet worked up stream. The average width of the patch is according to the hydrographic map 43 feet and the cutting to grade reads by the soundings in average 1.5 feet, which represents in the exhibit $\frac{60 \times 43 \times 1.5}{27} = 143.3$ cubic yards.

During last fall, when the crew was furnished by the contractor and the work was paid by the hour, 115 cubic yards were removed in the same time. The good condition of the machinery and the faithfulness of the present crew account for the better result in this spring. I expect with certainty of being able to report to you at the close of work in the fall the breaking of 750 cubic yards, to which 100 cubic yards of last fall added, will reduce the amount of rock to be broken at the foot of Moline chain from 2,505.8 to 1,655.8 cubic yards still remaining to be disposed of by the chisel.

Thirty thousand dollars is required for the breaking of 1,655.8 cubic yards of rock, and the dredging of 2,505.8 cubic yards afterward. To this sum must be added the necessary engineering expenses and contingencies, and for closing the work at these rapids a general survey by steamer and sounding-machine should be undertaken, and a map published for the benefit of navigation showing the boundaries of the channel

and guides erected on the shores for giving bearings to keep the channel. For this purpose and for the erection of flag-staffs, buoys, or marks of other description and device, as also for the work of cleaning some parts of the improved channels from rocks or bowlders brought in by the ice, a sum of $20,000 is required, which altogether would justify the request for a final appropriation of $50,000. With this last allotment the improving of the Rock Island rapids would disappear from the river and harbor bill on the end of the fiscal year June 30, 1879.

I cannot end this report to you better than repeating again the same words which I used in submitting my last annual report.

I most respectfully entreat you to recommend this remaining work to the favorable consideration of the higher authorities and Congress, as the subject of another and last appropriation for the fiscal year 1878–'79.

This last work represents the closing stone of an undertaking which stands in the history of improved rivers on this and the other side of the ocean unparalleled, and which, in the accomplished and undenied benefit extended to the navigation, proves to be of the greatest advantage to the bordering States of the river, and a perfect success in engineering. I take again pleasure in bringing to your notice the faithful and efficient services rendered by Assistant Engineer C. H. Beuck and draughtsman Mr. A. Stibolt.

All of which is respectfully submitted.

E. F. HOFFMANN.

Col. J. N. MACOMB,
Corps of Engineers, U. S. A.

P 4.

EXAMINATIONS, SURVEYS, AND CONTINGENCIES OF RIVERS AND HARBORS.

Under the above-named head of appropriations, certain minor surveys and examinations have been made by me during the past year, notably those in the vicinity of La Crosse, where changes in the river-channel were caused by the erection of accessory works of the bridge thrown over the Mississippi River by the Chicago, Milwaukee and Saint Paul Railway Company, a point where further special examinations are likely to be required before the river can be again brought under control at that point. To meet such surveys and examinations, the sum of $750, over and above the amount on hand, should be appropriated.

And in order to perfect the scheme of improving the Upper Mississippi River, between Saint Paul and the mouth of the Illinois River, there should be granted the further sum of $17,250, as there have been no examinations in that part of the river between Keokuk, Iowa, and the mouth of the Illinois River, a distance of some 160 miles, all of which should be thoroughly surveyed before the estimates for said scheme can be perfected.

P 5.

IMPROVING ILLINOIS RIVER.

Operations on this river have been conducted as heretofore, (in dredging and construction of dams and jetties.)

The work under the extended contract of William Patrick was completed October 31, 1876, and settlement made.

An open-market agreement was made with Mr. Patrick, October 17, (subject to the approval of the Chief of Engineers,) for the expenditure of the allotment of $10,000 from appropriation of August 14, 1876, at the same prices and under the same specifications as the late contract. The final estimate under this contract was rendered November 17, 1876.

On the 22d day of June, 1877, a contract was made with Mr. H. S.

Brown, of Hamilton, Ill., for the expenditure of the balance of the appropriation of August 14, 1876.

The work of dredging during the past season was interrupted by high water nearly the whole of the month of July, and in the construction of brush and stone dams but a very short season was favorable; advantage, however, was taken of the high stage of the river to make liberal deposits of the dredged material to act as substitutes for brush and stone dams. When within the limit of the "haul" this proves a very economical method, and, on the whole, quite satisfactory.

The equipment has been kept in an efficient condition, and the well-defined channels developed by soundings after dredging furnish good evidence that the work has been conducted faithfully.

The restoration of the obstructed channels at Spar Island and Sugar Creek Bars were made with promptness, thereby preventing the detention to trade that would have otherwise occurred. This demonstrates the importance of being always in readiness with a reserve fund and the necessary equipment; otherwise our improvement may at any time be rendered valueless.

As this cost of maintenance is estimated at less than $20,000 per annum, and it is to cover some 223 miles of river, making the cost per mile less than $90 per annum, I respectfully suggest that measures be taken to secure, at as early a date as practicable, the fund and equipment for this purpose.

During the year numerous surveys have been made of the several bars under improvement, also bars improved 1871 and 1872. Beardstown Bar, formerly the most formidable on the river, proves that this method of improvement is a success.

Our present available fund being so small, it suggests the expediency or necessity of studying the wants of navigators very carefully, and of confining our operations to such points as may from time to time be mentioned by them, in removing snags, sunken logs, &c., as they may be encountered during the low-water season.

A revised estimate is submitted by Mr. Brown covering the bars remaining unimproved and the dredging at harbors or landings, for which application has been made through petition; also the cost of the equipment above referred to. This estimate amounts to $145,000; of this sum $125,000 is to be expended in work, (under contract or otherwise,) and $20,000 for the purchase of the equipment whenever it shall be deemed expedient. This estimate is for the fiscal year ending June 30, 1879, and could profitably be expended during that year.

I beg leave to refer to the report of Assistant Engineer R. A. Brown for further details as to the operations and for interesting statistical and commercial information, particularly the internal-revenue collections of this State, which for the year 1876 prove to be 21½ per centum of the whole internal-revenue collections of the country.

Money statement.

July 1, 1876, amount available	$39,691 86	
Amount appropriated by act approved August 14, 1876	40,000 00	
		$79,691 86
July 1, 1877, amount expended during fiscal year	49,317 72	
July 1, 1877, outstanding liabilities	2,750 00	
		52,067 72
July 1, 1877, amount available		27,624 14
Amount (estimated) required for completion of existing project		145,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		145,000 00

REPORT OF MR. R. A. BROWN, ASSISTANT ENGINEER.

UNITED STATES QUARTER-BOAT MAJOR E. F. HOFFMAN,
At Grand Island, Mason County, Illinois, June 30, 1877.

COLONEL: I have the honor to submit the following report of operations for the improvement of the Illinois River during the fiscal year ending June 30, 1877:

At the close of the last fiscal year work was progressing at Slim Island Bar, (near Montgomery, Pike County,) the dredging-equipment consisting of 3 dredges, 1 tow-boat, with a full complement of scows, &c.

On the 6th July, the river having reached a stage of 10.7 feet above low-water and still rising—reports from the upper river also portending a still greater rise—work was suspended, and advantage taken of this event to have the tug-boat Innovator docked. This also proving a favorable opportunity for repairing the quarter-boat Hoffman, she was taken in tow for Peoria dry-docks on the evening of the 6th. After a slow passage to, and a protracted delay at, Peoria, our repairs were completed.

On the 28th we returned to Slim-Island Bar, but owing to the high stage of the river, work was not resumed until the 2d of August. During this month work was prosecuted at Slim Island, Bedford, Pilot's Peak, and Buckhorn Bars with the results as shown elsewhere.

The deposit of dredged material has been as follows, viz:

At Slim-Island Bar, principally on the dam closing the back chute.

At Bedford Bar, in a dike extending from the west shore, the approximate dimensions of which are, length 300 feet, mean width 90 feet, depth 3 feet.

At Pilot's Peak Bar, dike No. 1, 600 feet in length, mean width 90 feet, depth 6 feet. Dike No. 2, 400 feet in length, mean width 72 feet, depth 6 feet.

The material composing these dikes being of an unstable character, a brush and stone dam was constructed at this point, (length 520 feet,) permanently contracting the low-water cross-section to about one-half its former area.

During the month of September the work was continued at Buckhorn and Grand Pass Bars. (*Vide* tabular statement.) The stage of the river during this month proved very unfavorable for work, especially in the construction of dams, as the islands affording the principal material (willow) are generally submerged at a stage of 6 feet above low-water, and after coming to the surface, time is required for the necessary evaporation before the mud is in a condition for workmen to operate to advantage.

From the 2d to the 7th of October, inclusive, the dredges were employed at the newly-formed obstruction below the original Spar-Island Bar.

In compliance with your instructions, this work being completed, on the evening of the 7th the fleet got under way for Sugar Creek Bar, at which point it arrived on the morning of the 9th, and immediately commenced the work of removing snags deposited in the improved channel during the severe rains which occurred in the month of September, 1876. The magnitude of this deposit calls for more than a passing notice.

It will be remembered that a similar obstruction was formed at this point during the month of July, 1873, and in the winter of 1873 and '74; also that a channel was dredged through the bar during the seasons of 1874 and '75. This late deposit of snags, trees, and alluvion is of like nature and on as grand a scale, nearly.

The preliminary survey of September 21 last developed a dry bar, or dam, extending entirely across the river, (the soundings being reduced to low-water reference.)

At the mouth of the creek and some 150 feet each way, extending up and down the river, was a good depth of water, but the opposite side of the river proved shallow, showing that the current from the creek had sufficient force not only to keep *itself* clear, but that part of the river nearest its mouth also, and to push its charge of snags, trees, and alluvion to the opposite side of the river.

Some idea can be formed of the force of the storm, the agent of this mischief, from an inspection of the creek's banks. Large masses of alluvion, having become undermined, have fallen into the bed of the creek. These masses sometimes contain large trees, some standing upright, some leaning, and some lying in the stream; very many were found deposited, with masses of alluvion, brush, snags, logs, &c., in the river, below the mouth of the creek. The citizens describe it as being the most powerful storm they ever experienced. Should the like again occur, we may expect the destruction of our improved channel as before. The probabilities are, however, in favor of its remaining open a fair length of time.

The result of work for the month of October was the removal of the obstruction just below the original Spar Island Bar, the restoring of the channel at Sugar Creek Bar 120 feet wide for 600 feet through the upper section near the mouth of the creek, and 60 feet in width for 2,500 feet, leading into 3 feet depth at low-water. The character of this bar-material is such as to lead us to expect that the current during the past winter would produce sufficient scour to completely restore the channel provided in the spring of 1875.

The deposit of dredged material at Sugar Creek Bar was as re-enforcement to the dikes

formerly built. The brush and stone dam at Grand Pass Bar was completed to a height of about 1 foot above low-water, length 620 feet, reducing the low-water cross-section about one-half.

After the completion of the work of restoring the channel at Sugar Creek Bar, on the 7th November, the fleet was moved to Beardstown, and on the 8th commenced work at the bar opposite town. Operations continued here up to the 15th, when our fund became so reduced as to necessitate the dismissal of the equipment. The result of the work here is a channel 1,800 feet in length, 60 feet in width through the bar.

Experience of the past season demonstrates the necessity for making provisions to restore obstructed channels at short notice.

The removal of the newly-formed reef, or bar, near Spar Island, also of the *détris* at Sugar Creek Bar, during the month of October, enabled boats to continue in the trade throughout the season. Had the means been wanting to afford the above-mentioned relief, the river would have been practically closed to navigation (except for very light-draught boats) about the 10th of October, or until a rise in the river should occur.

At the close of the month of November the engineering party was reduced to four members; these were kept profitably employed during the winter in reducing and plotting notes of surveys made during the months of October and November for the purpose of planning work for the future, and to ascertain the condition of the channels improved in 1871 and '72.

During the winter, estimates were made and submitted showing comparative cost of improving West Point and Bath Chutes, the former passing west, the latter east of Grand Island. Instructions were received calling for further examinations, and a special report on the same, inquiring into all matters bearing upon the subject. This was also submitted, and permission was given to change the original project and improve Bath Chute by dredging and partially close West Point Chute, leaving a narrow sluice-way for the passage of ice-tows at any time when the remaining part of the chute is navigable for them.

CONTRACTS.

During the fiscal year work has been prosecuted under two contracts, viz: That of William Patrick, of Phœnix, Oswego County, New York, dated May 31, 1875, and extended to October 31, 1876.

On the 17th October, 1876, arrangements were made with Mr. Patrick (subject to the approval of the Chief of Engineers) to continue the work under the specifications and prices of the former contract, (dated May 31, 1875,) for the expenditure of the allotment of $10,000 appropriated August 14, 1876.

The final estimate on the contract bearing date May 13, 1875, was submitted November 4, 1876, and that for the special open-market agreement was submitted on the 17th of November, 1876.

On the 30th day of April, 1877, advertisements were issued from your office at Rock Island, calling for sealed proposals, up to 12 m. on the 8th of June, 1877, "for the prosecution of the work of dredging and construction of dams and jetties for the improvement of the Illinois River." On that day the only bid received was from Mr. H. S. Brown, the former superintendent for our late contractor. To him the work was awarded, and the contract executed on the 22d instant.

Work was immediately commenced at Bath Chute, Bar No. 1, at the head of Grand Island, with the result as shown in tabulated statement A.

The river having subsided to a stage sufficiently low as to allow us to make detailed surveys on the 27th of May, the quarter-boat was moved to the head of Grand Island Surveys were immediately commenced and plans matured for the resumption of work under the anticipated contract.

The engineering party was fully re-organized on the 1st of June, and preparations made to prosecute the work with vigor during the favorable stage of the river.

The amount of work performed during the fiscal year ending June 30, 1877, under the contract with William Patrick, of Phœnix, Oswego County, N. Y., dated May 31, 1875, was as follows, viz:

Localities.	Quantities.	Items.	Prices.	Amount.
Slim Island Bar	10,456 cubic yards	Earth-excavation	$0 28	$2,927 68
Bedford Bar	2,435 cubic yards	do	28	681 80
Pilot's Peak Bar	16,632 cubic yards	do	28	4,656 96
Buckhorn Bar	28,004 cubic yards	do	28	7,841 12
Grand Pass Bar	8,324 cubic yards	do	28	2,330 72
Spar Island Bar	7,458 cubic yards	do	28	2,088 24
Sugar Creek Bar	22,506 cubic yards	do	28	6,301 68
Bedford Bar	1 hour's work	Snagging	11 00	11 00
Pilot's Peak Bar	5 hours' work	do	11 00	55 00
Buckhorn Bar	$6\frac{40}{60}$ hours' work	do	11 00	73 33
Spar Island Bar	$\frac{45}{60}$ hour's work	do	11 00	8 25
Sugar Creek Bar	$45\frac{40}{60}$ hours' work	do	11 00	502 33
Pilot's Peak Bar	1,152 linear feet	Piling in dam	15	172 80
Do	591.4 cords	Brush in dam	2 50	1,478 50
Do	302.6 cubic yards	Stone in dam	2 50	756 50
Grand Pass Bar	1,248 linear feet	Piling in dam	15	187 20
Do	317.2 cords	Brush in dam	2 50	793 00
Do	260.9 cubic yards	Stone in dam	2 50	652 25
				31,518 36
The amount expended under this contract as per last annual report was				30,209 45
Total expended under this contract				61,727 81

Copy of final estimate (No. 9) of work done by Mr. Patrick under his contract for the improvement of the Illinois River, dated May 31, 1875.

Total amount of work done, including retained percentage	$61,727 81
Deduct former payment, as per receipted vouchers	55,555 03
Balance due	6,172 78

Under the open-market agreement with William Patrick, of October 17, 1876, the amount of work done is shown by the following statement:

Localities.	Quantities.	Items.	Price.	Amount.
Sugar Creek Bar	7,810 cubic yards	Earth excavation	$0 28	$2,186 80
Bar at Beardstown	4,191 cubic yards	Earth excavation	28	1,173 48
Sugar Creek Bar	1 hour's work with dredge	Snagging	11 00	11 00
Total estimate				3,371 28

Under the contract with H. S. Brown, dated June 22, 1877, the amount of work done is 11,000 cubic yards earth excavation at Bar No. 1, Bath Chute, at 25 cents, $2,750.00.

STATEMENT OF EXPENDITURES AND ESTIMATES.

In 1869 an allotment of $85,000 was made from the appropriation for the "repairs, extension, preservation, and completion of works for the improvement of rivers and harbors," which was ordered should be expended in dredging the bars and flats between the town of Henry and Copperas Creek, with the view of preparing a bottom for a 7-foot navigation when the proposed lock and dam at Copperas Creek should be completed, this being auxiliary to the work of constructing locks and dams by the State of Illinois.

Subsequently (see report of Mr. R. E. McMath, for the fiscal year ending June 30, 1872, report of Chief of Engineers,) an estimate was made for the improvement of the river (covering all of the remaining bars) by dredging and construction of low dams for contraction of channel.

This estimate, as has been before submitted, was $391,912.00.

There has since been appropriated:

In 1870	$100,000 00
1873	20,000 00
1874	75,000 00
1875	75,000 00
1876	40,000 00
Total expended and pledged for the work	310,000 00
Balance to be appropriated under this estimate	81,912 00

MATERIAL RESULTS OF THE YEAR'S WORK.

Dredging.

Channels have been provided through the following bars, viz: Slim Island, Bedford, Pilot's Peak, Buckhorn, Grand Pass, and Spar Island, (No. 2,) a partial improvement at Beardstown made; the channel at Sugar Creek Bar restored, and the improvement at bar No. 1, Bath Chute, nearly completed.

For details see tabulated statement A.

Dams and jetties.

As mentioned elsewhere, the past season has proved very unfavorable for the construction of brush and stone dams. This high stage of the river, however, aids materially in the construction of earth-dikes with dredged material. A liberal deposit of this nature, in many cases, answers very well as a substitute for the brush and stone dam work, and, when within the limits of our "haul," is entirely without cost.

Surveys.

During the year detailed surveys have been made (both before and after dredging) of Pilot's Peak, Buckhorn, Grand Pass, Spar Island, and Sugar Creek Bars, also bar at Beardstown, and part of Bath Chute; and preliminary surveys of Spar Island, Sugar Creek, West Point Chute, (some 7 miles in length,) Sangamon, Toll-Gate, and Beardstown Bars; also bar at Beardstown, Devil's Elbow Bar, and one-half of Bath Chute. This work has been prosecuted under very many difficulties. The prevailing high stage of the river has crowded the base-lines into the willows and timber, causing very much clearing to enable the assistants to take the necessary observations for locating soundings.

Permanence of the improvement.

The platting of the notes of the survey of Beardstown Bar, made in November last develops a 4-foot depth of channel through the bar, at low water, a distance of 5,000 feet. As this was one of the most formidable obstructions on the river, prior to its improvement in 1871 and 1872, and the bar material being of such a character as to lead to some misgivings as to the permanency of the work, we should look upon this case as a good test of the merits of this system of improvements for this river.

Improvements of harbors or landings.

Repeated applications, both written and verbal, have been received, asking for a small amount of work, by dredging, at several landings on the river. Upon this subject I submitted a special report, dated July 14, 1876, an extract from which I will here insert, viz: "Concerning the improvement of harbors or landings, I wish to state, that although it may appear at first thought to be out of our line of work, yet the statement in the petition of interested parties, heretofore submitted, is worthy of consideration. The local trade of the river, especially in the lower section, is quite important, and the more accessible the landings the more readily and cheaply can produce, &c., be transferred. The time of the boats' retention at these points is full as valuable as the time occupied in passing over the bars. Many of the towns at these landings are quite insignificant and of minor importance.

The adjacent country, being highly improved and thickly settled, would no doubt be materially benefited by these improvements. Producers are the parties more directly interested.

After mature deliberation I have arrived at the conclusion that it would not be inex-

pedient to apply the amount of funds estimated below in this direction, feeling confident that such a project will well subserve both commercial and producing interests.

The points where this work is required are Peoria, Beardstown, Meredosia, Naples, Florence, Montezuma, Eastport, and Columbiana.

Estimate of cost.

Eight landings at a mean of $500 each	$4,000 00
Engineering and contingencies, 25 per cent	1,000 00
Total	5,000 00

I most respectfully recommend that the sum of $5,000 be added to the revised estimate of funds wanting for the completion of this work.

REVISED ESTIMATE OF COST OF COMPLETING THE IMPROVEMENT.

For the narrow channel.

In my last annual report an estimate was submitted for the completion of the improvement below Big Blue River Bar. With the fund then available and the anticipated appropriation of August 14, 1876, no doubt was entertained of our ability to provide a channel throughout this section of the river, but, after the completion of the work at Slim Island, Bedford, Pilot's Peak, Buckhorn, and Grand Pass Bars, our attention was called to the restoring of the channel at Sugar Creek Bar; this exhausted our fund, but with the allotment of $10,000 from the appropriation of August 14, 1876, we were enabled to re-open this channel and make a partial improvement of bar at Beardstown. Here our new fund was so far reduced as to oblige us to suspend operations on the 15th day of November, 1876.

The bars remaining unimproved are as follows, viz:

In the lower river, (below Naples.)

List of bars.	Estimated cubic yards.
Big Blue River, (partly improved in 1872)	20,000
Bevington	14,000
Florence	4,000
Atwell's	11,000
Silver Creek	40,000
Hurricane Island	8,000
Twelve Mile Island	25,000
Six-Mile Island	30,000
Total cubic yards, (approximate)	152,000

In the upper river, (from Naples to Havana.)

Meredosia Island, Meredosia, Wilson's Island, Eagle Island, Indian Creek, Beaver Dam, bar at Beardstown, Sugar Creek Island, Sangamon, Bath Chute, Grand Island, Spoon River Bars. Approximate amount of earth excavation is 300,000 cubic yards.

RÉSUMÉ.

In the lower river	152,000 cubic yards.	
In the upper river	300,000 cubic yards.	
Total	452,000 cubic yards at 25 cents	$113,000 00
7,500 linear feet of dam at $3.33⅓		25,000 00
Engineering and contingencies		12,000 00
Estimated cost of improving eight harbors		5,000 00
Total estimate		155,000 00
Approximate amount of available fund June 1, 1877		30,000 00
Amount required to be expended in work		125,000 00

Could an appropriation for this amount ($125,000) be secured, to be expended in work under contract, and the elements prove favorable, this improvement could be completed as estimated by the close of the fiscal year ending June 30, 1879.

MAINTENANCE.

To avoid any delay in the matter of securing an equipment to be owned and operated by the Department direct for the purpose of giving additional width to our present improved channel, also to work in restoring obstructed channels whenever a necessity for such work occurs, I would most respectfully renew the suggestion in former reports that a sum of $20,000 be added to this "estimate of funds required to be expended in work," making the total sum desirable for the fiscal year ending June 30, 1879, $145,000. This amount could profitably be expended in the manner specified above.

PLANS FOR THE FISCAL YEAR ENDING JUNE 30, 1878.

Owing to the small amount of funds available at the present date, the plans for the ensuing year will be, after the improvement of Bath Chute by dredging and removing logs and leaning trees, (also the partial closing of West Point Chute,) to work at such points as may from time to time be suggested by navigators, providing such can be done with due economy and will be for the general interest of the public.

EQUIPMENT.

The present plant is as reported last season, and is in as efficient a condition. During the past year it has been under the direct management of the present contractor, Mr. H. S. Brown. The amount of work performed and the results obtained give general satisfaction.

The surveys after dredging the past season develop a better-defined channel than has heretofore been obtained since my connection with the work.

Abstract of bids for the improvement of the Illinois River, opened 12 m. June 8, 1877, by Col. J. N. Macomb, Corps of Engineers, United States Army, at Rock Island, Ill.

Number of bidder.	Name and residence of bidder.	Name of guarantor.	For earth-excavation, (dredging,) 50,000 cubic yards.		For working one or more dredges, manned and equipped complete, 100 hours.		For furnishing and driving piles, 2,000 linear feet.		For furnishing and putting in place brush, 600 cords.		For furnishing and putting in place stone, 600 cubic yards.	
			Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	Rate.	Amount.	Rate.	Amount.
1	H. S. Brown, Hamilton, Hancock County, Illinois.	George M. Case and William Patrick.	$0 25	$12,500	$10 00	$1,000	$0 15	$300	$2 50	$1,500	$2 00	$1,200

Abstract of contracts for improving the Illinois River in force during the fiscal year ending June 30, 1877.

Name and residence of contractor.	Date of contract.	Subject of contract.	Earth-excavation, (dredging,) per cubic yard.	For furnishing and driving piles, per linear foot.	For furnishing and putting in place—		For working one or more dredges, manned and equipped, each per hour.	Remarks.
					Brush, per cord.	Rubble-stone, per cubic yard.		
Wm. Patrick, Phœnix, Oswego County, New York.	May 31, 1875	Material and labor.	$0 28	$0 15	$2 50	$2 50	$11 00	Contract completed October 31, 1876.
H. S. Brown, Hamilton, Hancock County, Illinois.	June 22, 1877	Material and labor.	25	15	2 50	2 00	10 00	

A.—*Table showing the amount of work performed and results obtained for the improvement of the Illinois River during the fiscal year ending June 30, 1877; to accompany annual report of Col. J. N. Macomb, Corps of Engineers, United States Army.*

Date.		Name of bar.	Cubic yards of earth-excavation.	Price per cubic yard.	Cost of dredging.	Dimensions of channel at low water.						Time of dredge employed by the hour, and character of work.		Cost per hour.	Total cost of time-work.
						Before improvement, (approximate.)			After improvement.						
Year.	Month.					Length.	Width.	Depth.	Length	Width.	Depth.	Casting on dams.	Snagging.		
						Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	H. m.	H. m.		
1876	July and August	Slim Island	10,456	$0 28	$2,927 68	3,400	3.0	3.0	3,400	140	4.0	....	....	....	....
1876	August	Bedford	2,435	28	681 80	400	......	3.0	400	140	4.0	....	1 00	$11	$11 00
1876	August	Pilot's Peak	16,632	28	4,656 96	3,400	......	3.0	3,400	140	4.0	....	5 00	11	55 00
1876	August and September	Buckhorn	28,004	28	7,841 12	5,200	......	2.8	5,200	140	4.0	....	1 50	11	20 17
1876	September	Grand Pass	8,324	28	2,330 72	2,300	......	3.0	2,300	140	4.0	....	....	....	....
1876	October	Spar Island	7,458	28	2,088 24	......	......	......	......	......	......	....	45	11	8 25
1876	October and November	Sugar Creek	30,316	28	8,488 48	......	......	......	......	......	......	....	46 40	11	513 33
1876	November	At Beardstown	4,191	28	1,173 48	......	......	......	......	......	......	....	....	....	....
1877	June	Bath Chute, No. 1	11,000	25	2,750 00	......	......	......	......	......	......	....	....	....	....

Date.		Name of bar.	Construction of dams and jetties.								Remarks.
Year.	Month.		No. of linear feet.	Cost per linear foot.	No. of cubic yards.	Cost per cubic yard.	Cost of backing.	Total cost.	Cost per cubic yard, gross.	No. of linear feet of dike built with dredged material.	
1876	July and August	Slim Island	......	......	......	......	......	......	......	......	The dam of 1874 backed with dredged material.
1876	August	Bedford	......	......	......	......	......	......	......	300	One earth dike built.
1876	August	Pilot's Peak	520	$4 63	3,106	$0 77.5	......	$2,407 86	$0 77.5	1,000	Two earth dikes built.
1876	August and September	Buckhorn	......	......	......	......	......	......	......	2,000	Two earth dikes built.
1876	September	Grand Pass	620	2 63.3	1,764.6	92.5	......	1,632 45	92.5	600	One earth dike built.
1876	October	Spar Island	......	......	......	......	......	......	......	250	One earth dike built.
1876	October and November	Sugar Creek	......	......	......	......	......	......	......	......	Old channel restored, and old dikes re-enforced.
1876	November	At Beardstown	......	......	......	......	......	......	......	......	
1877	June	Bath Chute, No. 1	......	......	......	......	......	......	......	......	

STATISTICAL AND COMMERCIAL INFORMATION.

For the items under this head embodied in my report I am indebted to Messrs. John Hilt, esq., special deputy collector, port of Chicago; John F. Long, esq., surveyor of customs, port of Saint Louis; the collectors of the several internal-revenue districts mentioned in tabulated statement, and to George H. Morgan, secretary of the Merchants' Exchange of Saint Louis.

Attention is respectfully called to the amount of internal-revenue collections for the State of Illinois for the fiscal year ending June 30, 1876, viz: \$23,699,132.27; this being 21.5 per centum of the total internal-revenue collections of the country for that year.

I can offer no more weighty argument showing the importance or expediency of securing liberal appropriations for internal improvements than the above.

The tabular statements furnished under this head are intended to exhibit the importance of this water-route as compared with others.

I regret my inability to secure commercial statistics from the upper river.

The trade from Bath, Havana, Liverpool, Kingston, Lancaster, Pekin, Peoria, Lacon, Chillicothe, Henry, Peru, and La Salle, to Chicago, via the Illinois and Michigan Canal, is not mentioned. This must amount to a large sum.

The coal-trade of Kingston, as reported by the superintendent of the mines, Mr. M. O'Shaughnessy, amounts to, annually—

	Tons.
Shipments to Chicago	35,000
Supplied to boats on the river	20,000
Total annual products	55,000

The ice-trade is stated to amount to some 150,000 tons annually, the larger part of which is transported from La Salle and Peru to Saint Louis and points below.

Statement showing the movement in flour and grain for 1876 by the following routes.

RECEIPTS.

By—	Flour.	Wheat.	Corn.	Oats.	Rye.	Barley.
	Bbls.	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*
Upper Mississippi River boats	51,040	578,639	305,330	1,248,760	20,732	377,290
Lower Mississippi River boats	63,909	455,720	15,780	311	1,170	5,866
Illinois River boats	13,577	616,223	399,269	36,386	11,718	33
Missouri River boats	4,733	393,900	932,586	11,439	11,990	1,767
Ohio, Cumberland, and Tennessee River boats	61	1,636	....	....	....	....
Red, Ouachita, Arkansas, and White River boats	....	3,480	....	....	20	....

EXPORTS.

By—	Flour.	Wheat.	Corn.	Oats.	Rye.	Barley.
	Bbls.	*Bush*	*Bush.*	*Bush.*	*Bush.*	*Bush.*
New Orleans boats	452,011	37,166	2,379,982	1,225,669	688	5,325
Vicksburg boats	224,605	5,679	144,700	186,777	2,988	343
Memphis boats	81,185	29,218	15,463	106,785	839	933
Ohio, Cumberland, and Tennessee River boats	10,503	1,332	59,325	176	8,615	432
Upper Mississippi River boats	10,343	47,821	1,625	1,131	356	8,356
Illinois River boats	36,361	48,895	1,600	162	144	1,803
Missouri River boats	177	54	....	365	108	40

Statement showing the amount of freight in tons received at Saint Louis by river for five years.

Rivers.	1876.	1875.	1874.	1873.	1872.
Upper Mississippi	224,860	198,100	231,060	281,175	242,584
Lower Mississippi	147,185	128,020	169,780	226,535	295,960
Illinois	129,940	153,995	192,770	125,715	175,370
Missouri	50,345	30,160	44,830	38,630	26,895
Red, Ouachita, Arkansas, and White	100	100	340	1,075	3,720
Ohio, Cumberland, and Tennessee	136,325	153,150	93,985	127,925	119,390

Statement showing the amount of freight in tons shipped from Saint Louis by river for five years.

Rivers.	1876.	1975.	1874.	1873.	1872.
Upper Mississippi	93, 360	96, 225	95, 800	61, 966	55, 235
Lower Mississippi	379, 970	367, 235	469, 065	525, 445	543, 666
Illinois	20, 560	18, 470	13, 740	11, 695	15, 930
Missouri	19, 300	25, 100	20, 390	27, 810	27, 536
Red, Ouachita, Arkansas, and White	....	1, 480	5, 445	34, 640	32, 190
Cumberland and Tennessee	3, 015	1, 560	2, 225	2, 040	2, 240
Ohio	83, 960	129, 025	100, 660	119, 660	127, 985

Arrivals and departures of steamboats and barges, 1876.

ARRIVALS.

1876.	Upper Mississippi.	Lower Mississippi.	Illinois.	Missouri.	Arkansas and White.	Cumberland and Tennessee.	Ohio.	Total steamers.	Barges and canal-boats.	Tons of freight received.
January	37	59	11	.....	....	2	8	117	27	27, 080
February	34	53	15	....	1	......	13	116	50	31, 060
March	60	80	50	3	......	2	17	212	114	99, 155
April	77	66	38	9	.....	4	14	208	85	86, 995
May	107	58	34	17	1	2	21	240	87	93, 475
June	92	56	23	16	......	1	12	200	108	76, 965
July	98	54	25	14	......	2	11	204	48	54, 940
August	101	52	32	18	......	2	10	215	36	54, 440
September	98	50	25	13	......	1	7	194	33	53, 290
October	105	66	22	10	.....	2	7	212	51	62, 685
November	96	62	23	6	......	1	7	195	39	48, 135
December	3	5	1	.....	....	.....	.....	9	5	1, 175
Total	908	661	299	106	2	19	127	2, 122	683	688, 735

DEPARTURES.

1876.	Upper Mississippi.	Lower Mississippi.	Illinois.	Missouri.	Cumberland and Tennessee.	Ohio.	Total steamers.	Tons of freight received.
January	34	52	12	....	1	7	106	39, 735
February	35	57	15	1	....	8	116	43, 725
March	62	83	48	7	4	10	214	82, 860
April	83	50	36	15	1	15	209	64, 905
May	107	58	32	18	2	22	239	63, 970
June	99	53	25	16	2	12	207	64, 975
July	99	50	24	19	2	12	206	52, 570
August	100	50	32	18	2	12	214	48, 151
September	104	49	24	13	2	7	199	41, 543
October	99	72	21	8	3	9	212	52, 170
November	88	65	20	2	2	8	185	41, 040
December	1	1	....	....	....	....	11	5, 735
Total	911	658	289	117	21	122	2, 118	600, 100

CUSTOMS-REVENUE.

The work of improving the Illinois River is entirely within the customs-district of New Orleans, and extends from La Salle, 97 miles from Chicago, to Grafton, on the Mississippi, 46 miles from Saint Louis.

The total length of the section of river is 223 miles by survey, or 269 miles by steamboatmen's card-distances.

The amount of customs-revenue collected in fiscal year ending June 30, 1876, was—

At Chicago	$1,667,185 08
At Saint Louis	1,568,759 31

The tonnage of the Illinois River, as enrolled at the port of Saint Louis, is 20,253, (including ice-barges.)

INTERNAL REVENUE.

The internal-revenue districts directly connected with the Illinois River and the Illinois and Michigan Canal; and the amount of collections reported, are as follows, viz:

Name of collector.	Post-office or residence.	For the year ending—	Amount.
1. J. D. Harvey	Chicago	Dec. 31, 1876	$8,971,146 26
2. N. B. Allen	Aurora	Dec. 31, 1876	287,786 30
4. John Tillson	Quincy	June 30, 1876	1,775,135 11
5. Howard Knowls	Peoria	Dec. 31, 1876	8,527,072 71
8. J. Merriam	Springfield	Feb. 28, 1877	2,755,009 50
Total for State of Illinois		June 30, 1876	23,099,132 27

Being 21.5 per cent. of the total internal-revenue collections of the country.

Transactions at the custom-house, Saint Louis, Mo., compiled by Special Deputy Collector Henry P. Wyman.—Exhibit of comparative receipts from all sources at the port of Saint Louis, Mo., during the last fifteen years.

Year.	Import-duty.	Tonnage-tax.	Hospital-tax.	Inspections.	Storage.	Official fees.	Collections in coin.	Collections in currency.	Total collections.
1861	$14,425 15	$3,228 00	$2,304 60	$771 00	$593 48	$585 50	$14,425 15	$4,184 58	$18,609 73
1862	20,404 70	4,191 20	4,550 60	3,342 25	950 33	1,661 80	20,404 70	10,614 98	31,019 68
1863	36,622 09	24,916 85	3,644 60	4,194 00	436 50	1,785 15	36,622 09	13,288 25	49,910 34
1864	76,448 43	24,104 00	6,185 55	5,636 00	408 45	1,890 30	76,448 43	18,311 50	94,759 92
1865	586,407 07	30,259 25	10,271 10	18,848 05	729 74	5,410 40	586,407 07	60,176 14	654,583 21
1866	785,651 30	24,435 22	8,465 50	11,145 70	424 98	4,541 30	785,651 30	49,284 48	834,935 78
1867	1,236,798 06	27,491 70	8,556 18	15,571 00	2,403 24	3,558 15	1,236,798 06	60,457 82	1,297,255 88
1868	1,403,997 64	16,483 57	6,244 64	14,044 83	1,383 18	3,880 15	1,403,997 64	53,988 02	1,457,985 66
1869	1,711,256 19	Abolished ..	6,619 98	14,366 92	2,487 42	1,890 00	1,711,256 19	52,856 12	1,764,112 31
1870	1,996,083 49	.. do	7,003 64	14,040 49	1,390 31	2,482 65	1,996,083 49	41,400 66	2,037,484 15
1871	1,874,907 29	...do	10,590 50	16,306 60	1,226 36	2,278 80	1,874,907 20	30,402 26	1,905,309 55
1872	1,697,563 27	...do	11,325 78	16,114 57	2,459 09	2,587 50	1,697,563 27	32,486 94	1,730,050 21
1873	1,376,466 32	...do	11,206 75	14,512 98	1,829 45	2,630 80	1,376,466 32	30,179 98	1,406,646 30
1874	1,674,116 53	...do	11,868 34	13,895 26	1,742 00	1,949 65	1,674,116 53	29,475 25	1,703,591 78
1875	1,159,849 17	...do	9,578 53	13,022 72	1,653 00	2,099 45	1,159,849 17	26,353 70	1,186,202 87
1876	1,748,374 30	...do	12,005 81	13,700 94	1,168 00	2,550 00	1,748,374 30	28,994 75	1,777,369 05

CUSTOM-WAREHOUSE TRANSACTIONS, PORT OF SAINT LOUIS, DURING 1876.

	Foreign value warehoused.	Duty on warehousals.	Foreign value withdrawn.	Duty paid on withdrawals.
In warehouse December 31, 1875	$75,907 00	$46,636 00		
Transactions during the year	2,371,159 00	1,448,069 72	$2,430,923 00	$1,478,984 21
Total	2,447,066 00	1,494,705 72	2,430,923 00	1,478,984 21
In warehouse December 31, 1876	14,594 00	14,647 33		

Dutiable value of foreign imports into Saint Louis.

1869	$3,272,276	1873	$4,055,000
1870	3,848,000	1874	4,469,000
1871	5,129,000	1875	2,292,000
1872	5,060,000	1876	3,100,000

Duty collected last four years.

1873	$1,376,466 32	1876	$1,748,374 30
1874	1,674,116 53		
1875	1,159,849 17	Total	5,958,806 30

Statement of the tonnage of the port of Saint Louis for the last eleven years. Compiled by Mr. Nelson Young, deputy surveyor. Copied from the Saint Louis Globe-Democrat.

Year.	Admissions to marine hospital.	Hull and boiler inspection.	Steamers permanently enrolled.		Steamers temporarily enrolled.		Total steamers.		Barges permanently enrolled.		Barges temporarily enrolled.		Total barges.		Grand total of all vessels.	
			No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.
1866	911	189	209	96,683.57	.....	....	209	96,683.57	70	13,962.76	.....	....	70	13,962.76	279	110,646.33
1867	697	203	210	87,876.18	.....	....	210	87,876.18	100	26,962.82	.....	....	100	26,992.62	310	114,869.00
1868	646	191	181	77,256.5	16	4,414.40	197	81,701.91	197	31,004.79	....	....	107	34,004.79	304	115,706.70
1869	708	167	142	62,056.21	24	11,308.71	165	73,364.92	76	27,553.87	6	925.03	82	28,478.90	248	101,843.82
1870	526	177	147	67,092.62	25	8,880.41	174	75,973.03	69	29,418.36	15	2,547.44	84	31,992.80	256	107,965.93
1871	407	172	143	66,944.40	24	6,815.15	167	73,759.55	74	32,068.84	11	2,704.58	85	31,773.42	252	108,532.97
1872	501	152	139	64,489.30	16	6,055.30	155	70,544.60	96	43,349.67	11	1,890.14	107	45,298.81	262	115,784.41
1873	610	147	158	76,722.84	12	1,993.92	170	78,716.76	154	56,098.34	5	2,184.13	159	58,298.97	329	137,003.73
1874	646	150	152	67,795.92	13	3,181.87	165	70,977.79	161	55,333.00	2	102.52	163	55,405.52	328	126,382.81
1875	740	148	151	63,044.23	15	2,394.12	166	65,398.35	151	52,597.89	4	1,652.97	155	54,250.86	321	119,649.21
1876	625	147	162	63,566.81	9	1,749.11	171	65,315.92	176	60,297.16	3	1,229.51	176	61,526.67	350	126,862.59

DRAW-BRIDGES, (SHEER-BOOMS AND BOOM-PIERS.)

As the above subject is frequently agitated by navigators of the Illinois River, and repeated requests made that protection-works be constructed to facilitate the passage of boats and tows through bridges, and as the act of Congress approved March 3, 1875, only makes provision for bridge-piers on the Mississippi River, I respectfully ask that a copy of your letter on this subject to the Chief of Engineers, dated June 15, 1874, be here inserted.

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., June 15, 1874.

GENERAL: I have the honor to acknowledge the receipt of your favor of the 11th instant, calling upon me for an early report upon the inclosed printed act, first session Forty-third Congress, H. R. 3379, by the Hon. Z. Chandler, chairman of Committee on Commerce, United States Senate, which was referred to the Hon. Secretary of War for any "information as to the necessity of proposed law, together with suggestions or recommendations."

The papers are respectfully returned with the following suggestions and recommendations:

1st. That the bill should be made to include in its provisions the Illinois River, and its bridges and piers.

2d. Instead of making it mandatory that *all bridge-piers* on the Mississippi River and Illinois River should have sheer-booms on their up-stream ends, it should be enacted that sheer-booms and boom-piers be placed above such pier or piers in said rivers, and of such construction as the Army engineer having charge of the improvement of said rivers may direct, the same to be constructed and maintained at the expense of such companies or owners of the piers in question.

The necessity of such a law is obvious to the navigators of those rivers and to the engineers in charge of the river improvements, and its enactment would conduce greatly to the facilitating of the navigation of said rivers.

I remain, very respectfully, your most obedient servant,

J. N. MACOMB,
Colonel of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

Accompanying this report are maps of Slim Island and Bedford: (1) Pilot's Peak (2) Buckhorn, (3) and Grand Pass (4) Bars—scale 800 feet to 1 inch, ($\frac{1}{9600}$)—showing the system pursued in dredging, and the contraction of channel by means of brush and stone dams, and earth dikes built with dredged material. Also a copy of water-record for the fiscal year.

In conclusion, I take pleasure in stating that the several members of the engineer force merit your favor for the faithful performance of the duties assigned them.

The present organization is complete; the members are energetic and reliable.

Very respectfully submitted.

Your most obedient servant,

R. A. BROWN.

Col. J. N. MACOMB,
Corps of Engineers, U. S. A.

Illinois River improvement—water record from July 1, 1876, to June 29, 1877.

Day.	July, 1876.	August.	September.	October.	November.	December.	January, 1877.	February.	March.	April.	May.	June.
1	9.6	9.9	3.3	4.7	4.4	6.4	3.0	4.0	5.8	11.2	12.3	8.2
2	9.6	9.5	4.5	4.3	5.3	6.3	3.0	5.3	5.8	11.7	12.1	7.9
3	9.8	9.0	4.5	4.2	5.6	6.3	3.0	6.1	5.8	12.2	12.2	7.6
4	10.3	8.7	4.0	4.4	6.5	6.2	3.0	6.5	5.8	12.5	12.3	7.3
5	10.7	8.3	3.6	4.2	6.9	6.0	3.0	6.8	5.8	12.9	12.3	7.3
6	......	8.1	5.5	4.0	6.9	5.8	2.9	7.0	5.8	13.2	12.3	7.3
7	......	7.4	7.6	3.9	6.9	5.6	2.6	7.2	5.7	13.4	12.3	7.3
8	......	7.1	9.0	.....	5.8	5.5	2.6	7.4	5.7	13.7	12.3	7.3
9	13.4	6.7	10.1	4.8	6.0	5.1	2.6	7.1	5.6	14.0	12.3	7.3
10	13.1	6.4	10.5	4.7	6.3	5.1	2.6	7.1	5.5	14.2	12.3	7.2
11	12.8	6.1	10.7	4.5	6.3	5.0	2.6	7.1	5.5	14.4	12.3	7.0
12	12.7	5.9	10.8	4.3	6.3	4.9	2.5	7.1	5.5	14.5	12.3	6.8
13	12.7	5.6	10.8	4.1	6.2	4.8	2.5	7.0	5.5	14.5	12.2	6.5
14	12.6	5.3	10.6	4.0	6.1	4.7	2.5	6.7	5.5	14.5	12.2	6.3
15	12.4	5.1	10.4	4.0	6.1	4.6	2.5	6.8	5.6	14.5	12.1	6.0
16	12.2	4.9	10.4	3.8	5.9	4.3	2.5	6.8	5.7	14.3	12.0	5.8
17	11.1	4.7	10.1	3.7	5.8	4.3	2.5	6.7	5.8	14.4	12.0	5.6
18	11.9	5.0	9.8	3.6	5.7	4.3	2.5	6.6	5.8	14.2	12.0	5.3
19	11.6	5.5	9.4	3.6	5.7	4.3	2.5	6.5	6.0	14.1	12.0	5.2
20	11.3	5.4	8.4	3.6	5.7	4.2	2.5	6.4	6.1	14.0	12.0	5.7
21	11.0	5.0	7.8	3.6	6.7	4.1	2.5	6.5	6.6	13.9	12.0	6.4
22	10.9	4.4	7.2	3.6	6.8	3.9	2.5	6.3	7.0	13.7	11.8	6.8
23	10.6	4.2	6.6	3.6	6.8	3.8	2.5	6.3	7.4	13.5	11.6	7.1
24	......	4.0	6.1	3.7	6.8	3.7	2.5	6.2	7.8	13.2	11.4	7.2
25	......	3.9	5.7	3.7	6.8	3.6	2.5	6.1	8.0	13.1	11.2	7.2
26	......	4.1	5.5	3.7	6.9	3.5	2.5	6.0	8.2	12.9	11.0	7.9
27	......	3.9	5.4	3.8	6.9	3.4	2.6	6.0	8.5	12.8	11.8	8.4
28	11.8	3.8	5.2	3.8	6.8	3.3	2.6	5.9	9.2	12.6	9.3	8.7
29	11.4	3.5	5.0	3.8	6.9	3.2	2.6	......	9.9	12.5	9.1	8.9
30	10.9	3.3	4.9	3.8	6.5	3.1	2.7	......	10.2	12.4	8.8	....
31	10.4	3.2	......	3.8	....	3.0	3.1	......	10.5	......	8.5	....
Mean	11.5	5.7	7.4	3.9	6.2	4.6	2.6	6.5	6.7	13.4	11.5	....

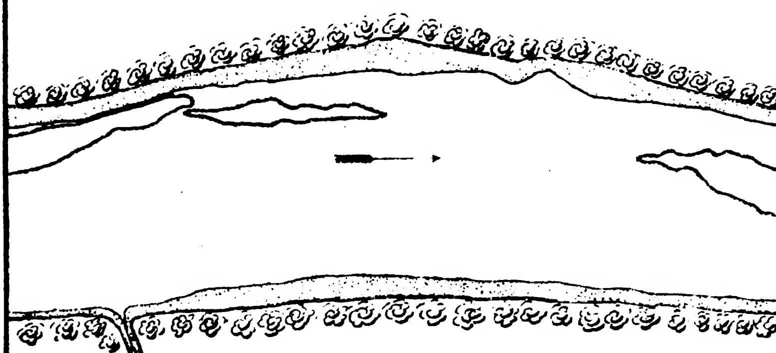
ILLINOIS RIVER IMPROVEMENT.

PILOT'S PEAK BAR.

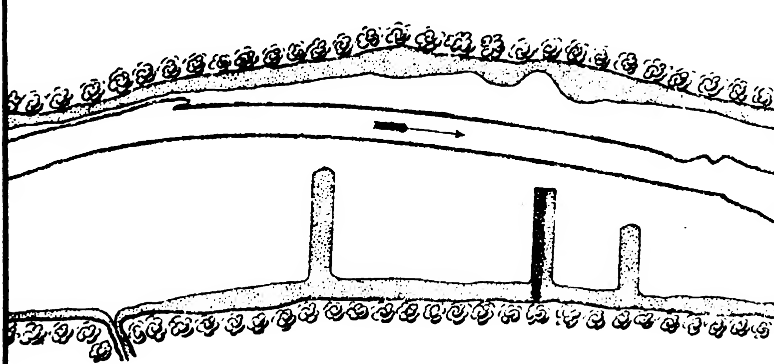
100 0 500 1000 2000 ft.

SCALE.

Sketch showing details of work, to be appended to the Annual Report to the Chief of Engineers, for the fiscal year ending June 30, 1877, by Col. J. N. Macomb, Corps of Engineers, U. S. Army.



BEFORE IMPROVEMENT.



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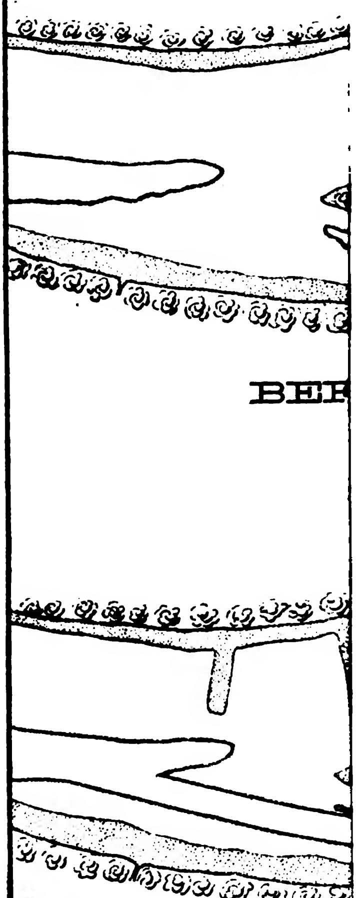


BEF

AFT

work on the concrete dike, to all of whom I am greatly indebted for the faithful and able maner in which they have performed all the duties devolving upon them.

Very respectfully, your obedient servant,

J. L. GILLESPIE,
Assistant Engineer.

Maj. F. U. FARQUHAR,
Corps of Engineers, U. S. A.

As reported in my last annual report, proposals for building the rolling-dams and for furnishing and putting in place gravel were opened June 29, 1876, but owing to the lateness of the season that the appropriation became available the contracts were not awarded until September 1, 1876. The contract for building the rolling-dams was made with Messrs. Cook & Folsom, and that for gravel-filling with Messrs. Henry & Abraham.

After due advertising contracts were made with Messrs. Cole & Hammond for furnishing the necessary lumber for remodeling the apron, and with Mr. Fendall G. Winston for furnishing and putting in the bowlders that are to form the enrockment at the foot of the apron. The abstracts of proposals received are hereto attached.

ABSTRACT OF APPROPRIATIONS MADE FOR THE PRESERVATION OF THE FALLS OF SAINT ANTHONY.

By act approved July 11, 1870	*$50,000 00
By act approved March 3, 1871	*50,000 00
By act approved June 10, 1872	*50,000 00
By act approved March 3, 1873	*50,000 00
By act approved June 23, 1874	125,000 00
By act approved March 3, 1875	100,000 00
By act approved August 14, 1876	120,000 00
	545,000 00
Original estimate for carrying out present project	529,726 31
Remaining to be appropriated	184,726 31

Money statement.

July 1, 1876, amount available	$3,062 38	
Amount appropriated by act approved August 14, 1876	120,000 00	
		$123,062 38
July 1, 1877, amount expended during fiscal year	64,081 86	
July 1, 1877, outstanding liabilities	482 12	
		64,563 98
July 1, 1877, amount available		58,498 40
Amount (estimated) required for completion of existing project		184,726 35

* These sums were used before the adoption of the present plan.

Abstract of proposals for filling excavations at the Falls of Saint Anthony, opened at 12 m., on Thursday, June 29, 1876, by Major F. U. Farquhar, Corps of Engineers, U. S. A.

Name and residence of bidder.	For furnishing and putting in place gravel-filling in the tunnel and east passage, 12,000 cubic yards.		For furnishing and putting in place gravel-filling west of Nicollet Island, 9,000 cubic yards.		Aggregate.	Remarks.
	Price.	Amount.	Price.	Amount.		
Martin Strong, Duluth, Minn	$0 63	$7,560 00	$0 63	$5,670 00	$13,230 00	Informal. Only one copy of proposals received.
Horace C. Henry and David T. Abraham, Minneapolis, Minn.	52½	6,300 00	24	2,160 00	8,460 00	Contract awarded.
John P. Nash, Saint Paul, Minn	1 25	15,000 00	95	8,550 00	23,550 00	
Thomas L. Rosser, Fendall G. Winston, and Philip B. Winston, Minneapolis, Minn.	57	6,840 00	29½	2,655 00	9,495 00	
Franklin Cook and Edgar Folsom, Minneapolis, Minn	33⅓	4,000 00	18	1,620 00	5,620 00	Informal. Duplicate bid not signed by guarantors or by Franklin Cook.
William Patrick, Phœnix, Oswego County, N. Y	85	10,200 00	40	3,600 00	13,800 00	
Matthew Frier and Thomas Daly, Minneapolis, Minn	49	5,880 00	35	3,150 00	9,030 00	Informal. No specifications attached to bid. No guarantors. No witnesses to signatures.
Joseph W. Smyth and John Donohue, Saint Paul, Minn	2 00	24,000 00	1 50	13,500 00	37,500 00	Informal. Only one copy of proposals received. No witnesses to signatures.
J. C. Lawrence, Minneapolis, Minn	73	8,760 00	47	4,230 00	12,990 00	Informal. Only one signature of guarantors witnessed.

Abstract of proposals for constructing two dams at the Falls of Saint Anthony, opened 12 m., on Thursday, June 29, 1876, by Maj. F. U. Farquhar, Corps of Engineers, U. S. A.

Name and residence of bidders.	For furnishing framing, bolting, and putting in place pine timber, 626,096 feet, board-measure.		For furnishing wrought-iron drift-bolts, 1¼ inches diameter; 13,308 pounds.		For furnishing wrought-iron drift-bolts, 1 inch in diameter; 30,048 pounds.		For furnishing wrought-iron drift-bolts, ¾ inch in diameter; 6,220 pounds.		For furnishing and putting in place sheet-iron ¾ inch thick; 45,500 pounds.		For furnishing and putting in place stone; 300 cords.		Aggregate.
	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.	
Sumner W. Farnham and Henry A. Dow, Minneapolis, Minn.*	$29 88	$18,707 75	$0 4½	$598 86	$0 4½	$1,352 16	$0 5	$311 00	$0 5½	$2,502 50	$8 00	$2,400 00	$25,872 27
J. C. Lawrence, Minneapolis, Minn†	26 00 ‡25 00 §10 00	16,914 80	4⅝	615 49	4⅝	1,389 72	5⅝	349 81	5⅝	2,559 37	8 00	2,400 00	24,229 25
Sumner C. Cutler and William D. Hale, Minneapolis, Minn.	25 00	15,652 40	4 7/16	590 54	4 7/16	1,333 38	4 7/16	276 01	4 7/16	2,019 06	9 75	2,925 00	22,796 39
Horace C. Henry and David T. Abraham, Minneapolis, Minn.	23 75	14,869 78	4½	598 86	4½	1,352 16	4½	279 90	5¼	2,388 75	5 00	1,500 00	20,989 45
Thomas L. Rosser, Fendall G. Winston, Philip B. Winston, Minneapolis, Minn.	27 00	16,904 59	4½	598 86	4½	1,352 16	4½	279 90	5½	2,502 50	7 00	2,100 00	23,738 01
Franklin Cook and Edgar Folsom, Minneapolis, Minn.‖	22 90	14,337 60	3¼	432 41	3⅝	1,089 24	4⅝	287 67	4⅝	2,104 37	4 00	1,200 00	19,501 29
William Patrick, Phœnix, Oswego County, New York.	34 00	21,287 26	8	1,064 61	8	2,403 84	8	497 60	10	4,550 00	10 00	3,000 00	32,803 34
Joseph W. Smyth and John Donohue, Saint Paul, Minn.¶	30 00	18,782 88	7½	998 10	7½	2,253 60	7½	466 50	7½	3,412 50	13 50	4,050 00	29,963 58
Donald Grant and Edmund H. Le May, Faribault, Minn.**	28 00	17,530 69	4	532 32	4½	1,352 16	5	311 00	9	4,095 00	8 00	2,400 00	26,221 17

* Informal. Only one copy of bid. No guarantors. No witnesses.
† Informal. No witness to guarantors. No seals attached.
‡ Two-inch pins.
§ One-and-a-quarter-inch pins.
‖ Contract awarded.
¶ Informal. Only one copy of bid. No witnesses to signatures.
** Informal. No witnesses to signatures.

Abstract of proposals for furnishing pine lumber at the Falls of Saint Anthony, Minn., opened June 25, 1877, by Maj. F. U. Farquhar, Corps of Engineers, U. S. A.

Name and residence of bidders.	For furnishing pine plank 4 inches thick, 20 ft. long, 116,000 ft., board-measure.		Pine plank 4 inches thick, 30 feet long, 20,000 feet, board-measure.		Pine plank 8 inches thick, 20 feet long, 233,000 ft., board-measure.		Pine plank 8 inches thick, 30 feet long, 40,000 feet, board-measure.		Pine timber 12 inches square, 20 ft. long, 411,000 ft., board-measure.		Pine timber 12 inches square, 30 feet long, 30,000 ft., board-measure.		Aggregate.
	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.	
Todd Haren, Leavitt & Co., Minneapolis, Minn...	$10 00	$1,160 00	$13 00	$260 00	$10 00	$2,330 00	$13 00	$520 00	$10 00	$4,110 00	$13 00	$390 00	$8,770 00
McMullen & Dickey, Minneapolis, Minn.........	9 75	1,131 00	11 70	234 00	9 65	2,248 45	11 48	459 20	9 48	3,896 28	11 33	339 90	8,308 83
Cole & Hammond, Minneapolis, Minn*	9 25	1,073 00	11 20	224 00	9 25	2,155 25	11 20	448 00	9 25	3,801 75	11 20	336 00	8,038 00
Barrows Bros. & Charles Reeve, Minneapolis, Minn.†	9 90	....	12 90	....	9 90	....	12 90	....	9 90	....	14 00	....	....

*Contract awarded to Cole & Hammond. †Informal. Only one copy. No seals.

Abstract for proposals for furnishing stone at the Falls of Saint Anthony, opened June 25, 1877, by Maj. F. U. Farquhar, Corps of Engineers, U. S. A.

Name and residence of bidders.	Price per cord.
McDougall & McLennan, Duluth, Minn	$17 90
Edgar Folsom, Minneapolis, Minn	19 50
Fendall G. Winston*	14 50
Breen & Young, Saint Paul, Minn	15 50

* Contract awarded to Fendall G. Winston.

Q 2.

IMPROVING THE MISSISSIPPI RIVER ABOVE THE FALLS OF SAINT ANTHONY, MINNESOTA.

No work was done last season. Work for this season commenced at Battle Rapids, 41 miles above Minneapolis, the last week in May. It is being done by hired labor, use being made of the steam crane-scow built in 1874. All that can be done during the present season is the bettering of the navigation at a few of the worst places on the river, viz, Battle Rapids, Houghton's Flats, Spring Rapids, and Dayton Rapids.

A light self-propelling dredge should be built, but the present appropriation is too small to build it and do any work. It is possible that the steam crane-scow can be fitted up with dredging apparatus and a stern-wheel. Estimates will be forwarded for this fitting up as soon as they can be made by competent persons.

The estimate for improving the Mississippi River between the Falls of Saint Anthony and Sauk Rapids (see page 452, Part II, Annual Report of the Chief of Engineers, 1875) was $144,667.50. Since this estimate there has been appropriated $20,000, leaving $124,667.50 to be still appropriated. If the work is to continue, at least $50,000 should be appropriated annually.

The whole commerce on this part of the river is carried on one small steamboat and its attendant barges.

Its navigation and the work of improvement of the river is seriously hindered by the running of loose logs from the pineries to Minneapolis.

ABSTRACT OF APPROPRIATIONS MADE FOR IMPROVING THE MISSISSIPPI RIVER ABOVE THE FALLS OF SAINT ANTHONY.

By act approved June 23, 1874*	$25,000
By act approved August 14, 1876	20,000
	45,000
Original estimate for the work between the Falls of Saint Anthony and Saint Cloud, Minn	$144,667 50
Remaining to be appropriated	89,667 50

* Made and expended before the adoption of the present project.

Money statement.

Amount appropriated by act approved August 14, 1876		$20,000 00
July 1, 1877, amount expended during fiscal year	$1,366 78	
July 1, 1877, outstanding liabilities	1,923 20	
		3,289 98
July 1, 1876, amount available		16,710 02
Amount (estimated) required for completion of existing project		124,667 50
Amount that can be profitably expended in fiscal year ending June 30, 1879		50,000 00

Q 3.

CONSTRUCTION OF LOCK AND DAM ON MISSISSIPPI RIVER AT MEEKER'S ISLAND, MINNESOTA.

No work has been done here, as no funds were available, because the parties holding the land-grant have not made any acceptable release, as required by the act approved March 3, 1875.

The State of Minnesota should annul the grant to the parties now holding the land-grant, and release the same to the United States.

Should it be determined to carry on this work, a sum not less than $300,0 ,0 should be appropriated for the fiscal year ending June 30, 1879.

Money statement.

July 1, 1876, amount available	$25,000 00
July 1, 1877, amount available	25,000 00
Amount (estimated) required for completion of existing project	922,121 46
Amount that can be profitably expended in fiscal year ending June 30, 1879	300,000 00

Q 4.

IMPROVING MINNESOTA RIVER.

No work was done last season, as no funds were available.

A contract was made July 3, 1877, with Messrs. Douglass & Winston Brothers, for removing snags, &c., commencing where the last work terminated, and working down stream.

Since the last annual report there has been no commerce on the river above Little Rapids, nor is it probable there will be any until the lock and dam at Little Rapids are built.

If boats could run during the whole season on the river, the work of pulling out snags, &c., would be of at least some temporary good, but until Little Rapids are made passable such work is useless.

The original estimate for removing snags, overhanging trees, &c., was $37,000, (see page 260, Annual Report of the Chief of Engineers for 1867.) In 1869 this estimate was increased by $15,000, (see page 191, Annual Report of the Chief of Engineers for 1869,) making a total of $52,000.

There has been spent $77,879.16 in removing snags, &c., and there are plenty more in the river.

Every high water brings in many snags.

At least $60,000 should be appropriated for commencing the construction of the lock and dam at Little Rapids.

ABSTRACT OF APPROPRIATIONS MADE FOR THE IMPROVEMENT OF THE MINNESOTA RIVER.

By act approved March 2, 1867	$37,500
By act approved July 11, 1870	10,000
By act approved March 3, 1871	10,000
By act approved June 10, 1872	10,000
By act approved March 3, 1873	10,000
By act approved June 23, 1874	*10,000
By act approved March 3, 1875	10,000
By act approved August 14, 1876	10,000
	107,500

Money statement.

July 1, 1876, amount available	$14 44	
Amount appropriated by act approved August 14, 1876	10,000 00	
		$10,014 44
July 1, 1877, amount expended during fiscal year	22 60	
July 1, 1877, outstanding liabilities	28 48	
		51 08
July 1, 1877, amount available		9,963 36
Amount (estimated) required for completion of existing project, (lock and dam, Little Rapids)		127,463 05
Amount that can be profitably expended in fiscal year ending June 30, 1879, (lock and dam, Little Rapids)		60,000 00

* Used in making survey of river.

Abstract of proposals for the removal of snags, &c., from the Minnesota River, opened July 2, 1877, by Maj. F. U. Farquhar, Corps of Engineers, U. S. A.

Names and residences of bidders.	For removing bowlders, 50 cubic yards.		For removing overhanging trees. 36″ diameter and upwards, 26.		30″ to 36″ diameter, 75.		20″ to 30″ diameter, 224.		6″ to 20″ diameter, 474.		4″ to 6″ diameter, 201.	
	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.
Farrell & Smyth, Saint Paul, Minn	....	$12 ‘0	$2 50	....	$2 00	....	$1 25	....	$0 75	....	$0 50	....
Douglass & Winston Brothers, Minneapolis, Minn	$0 05	2 50	75	$19 50	60	$45 00	50	$112 00	1 75	$829 50	25	$50 25
Warren & McDougall, Minneapolis, Minn	1 00	50 00	3 00	78 00	2 00	150 00	1 50	336 00	75	355 50	50	100 50
De Wolf & Hooper, Belle Plaine, Minn	75	37 50	2 50	65 00	2 40	180 00	2 20	492 80	1 50	711 00	75	150 75
Edgar Folsom, Minneapolis, Minn	2 00	100 00	2 70	70 20	2 65	198 75	2 00	448 00	75	355 50	25	50 25
Lantry & Bryant, Minneapolis, Minn	25	12 50	1 00	26 00	1 00	75 00	1 50	336 00	2 00	948 00	1 00	201 00
Rollin M. Douglass, Minneapolis, Minn	50	25 00	2 60	67 60	2 10	157 50	1 90	425 60	1 05	497 70	80	160 80
Webster & Haney, Henderson, Minn	2 74	137 00	3 99	103 74	2 98½	223 87½	1 99	445 76	1 49½	708 63	49½	99 49½

Names and residences of bidders.	For removing snags, &c. 36″ diameter and upwards, 47.		30″ to 36″ diameter, 102.		20″ to 30″ diameter, 212.		6″ to 20″ diameter, 496.		4″ to 6″ diameter, 143.		Aggregate.	Remarks.
	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.	Price.	Amount.		
Farrell & Smyth, Saint Paul, Minn	$15 00	....	$12 00	....	$10 00	....	$6 00	....	$3 00	....	....	Informal; signature of one of guarantors not complete.
Douglass & Winston Brothers, Minneapolis, Minn.	1 00	$47 00	1 00	$102 00	1 00	$212 00	6 00	$2,976 00	1 00	$143 00	$4,538 75	Contract awarded.
Warren & McDougall, Minneapolis, Minn	18 00	846 00	14 00	1,428 00	7 00	1,484 00	3 00	1,488 00	1 00	143 00	6,459 00	
De Wolf & Hooper, Belle Plaine, Minn	9 00	423 00	7 00	714 00	5 00	1,060 00	4 00	1,984 00	2 00	286 00	6,104 05	
Edgar Folsom, Minneapolis, Minn	8 00	376 00	6 00	612 00	5 00	1,060 00	3 00	1,488 00	1 75	250 25	5,008 95	
Lantry & Bryant, Minneapolis, Minn	2 00	94 00	2 00	204 00	2 00	424 00	4 75	2,356 00	2 00	286 00	4,962 50	
Rollin M. Douglass, Minneapolis, Minn	8 00	376 00	6 05	617 10	4 00	848 00	3 60	1,785 60	1 40	200 20	5,161 10	
Webster & Haney, Henderson, Minn	11 99	563 53	9 97	1,016 94	6 98½	1,480 82	4 00	1,984 00	2 00	286 00	7,049 79	

Q 5.

IMPROVING CHIPPEWA RIVER, WISCONSIN.

No work was done during the last fiscal year. A contract was entered into with Messrs. Winston, Douglass & Winston, July 2, 1877, for building brush and stone jetties at the mouth of the river.

The estimated cost of the work at the mouth was $27,300, (see page 709, Part I, Annual Report of Chief of Engineers for 1876.)

Owing to the low prices, the present appropriation will finish about half the work at this locality.

A lock and dam is being built on the middle of the rapids at the Lower Dalles, by a corporation under a contract with the city of Eau Claire and the authority of the State of Wisconsin.

The estimate of the cost of improving the river below Eau Claire was $139,892 50, (see Annual Reports of the Chief of Engineers for 1875 and 1876.) Of this amount, $64,102.50 are estimated as the cost of protecting the five high sand-banks below Eau Claire.

If the work of improving this river is to continue, I would recommend that Congress be asked to appropriate the above amount for protecting the high banks, and an additional sum of $20,000 to continue the work of building wing-dams and jetties.

Money statement.

Amount appropriated by act approved August 14, 1876		$10,000 00
July 1, 1877, amount expended during fiscal year	$3 94	
July 1, 1877, outstanding liabilities	24 24	
		28 18
July 1, 1877, amount available		9,971 82
Amount (estimated) required for completion of existing project		129,892 50
Amount that can be profitably expended in fiscal year ending June 30, 1879:		
For protecting high sand-banks	$64,102 50	84,102 50
For wing-dams	20,000 00	

Abstract of proposals for constructing jetties at the mouth of the Chippewa River, Wisconsin, opened June 30, 1877, by Maj. F. U. Farquhar, Corps of Engineers, U. S. A.

Names and residences of bidders.	For furnishing and putting in place brush—3,300 cubic yds.		For furnishing and putting in place stone—4,950 cubic yds.		Aggregate.	Remarks.
	Price.	Amount.	Price.	Amount.		
Winston, Douglass & Winston, Minneapolis, Minn.	$0 78	$2,574 00	$0 79½	$3,935 25	$6,509 25	Contract awarded.
John Gage, Watopa, Minn.	60	1,980 00	1 58	7,821 00	9,801 00	
Charles R. Read, Wabashaw, Minn.	1 15	3,795 00	1 20	5,940 00	9,735 00	
Warren & McDougall, Minneapolis, Minn.	84	2,772 00	1 29	6,385 50	9,157 50	
Farrell & Smyth, Saint Paul, Minn.	1 25	....	1 75	....	....	Informal; no seals attached to signatures of guarantors.
Edgar Folsom, Minneapolis, Minn.	1 49	4,917 00	1 79	3,860 50	13,777 50	

Q 6.

IMPROVING RED RIVER OF THE NORTH.

Except the fitting out of parties, no work has been done during the last fiscal year.

The work the present season will consist in—

1. Removing snags, bowlders, and overhanging trees, commencing at Moorhead and working down stream, by hired labor;
2. In making detailed surveys of the sites of the proposed lock and dam just below Goose rapids; and
3. In making an examination of the river below Frog Point, (the termination of the examination made in 1873.)

A report and amended estimate will be forwarded as soon as the field-notes can be worked up after the close of the season.

Except the lock and dam at Goose Rapids, the work of improving the river will consist principally in dredging. Either the United States or a contractor must build a dredge, if the work is to continue. A dredging-outfit will cost about $20,000. The cost of operating a dredge will be $8,530 per year.

I would recommend that Congress be asked to appropriate $30,000 for dredging.

If the lock and dam at Goose Rapids are to be built, not less than $100,000 should be appropriated to commence that work.

No complete estimate of the cost of improving the river can be made until the return of the field-party.

Money statement.

Amount appropriated by act approved August 14, 1876		$10,000 00
July 1, 1877, amount expended during fiscal year	$945 93	
July 1, 1877, outstanding liabilities	508 70	
		1,454 63
July 1, 1877, amount available		8,545 37
Amount (estimated) required for completion of existing project		
Amount that can be profitably expended in fiscal year ending June 30, 1879:		
For dredging	$30,000 00	130,000 00
For lock and dam at Goose Rapids	100,000 00	

APPENDIX R.

ANNUAL REPORT OF CAPTAIN WILLIAM R. KING, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1877.

UNITED STATES ENGINEER OFFICE,
Chattanooga, Tenn., August 11, 1877.

GENERAL: I have the honor to submit the following reports on the works under my charge for the fiscal year ending June 30, 1877.

Very respectfully, your obedient servant,

W. R. KING,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A.

R 1.

IMPROVEMENT OF TENNESSEE RIVER ABOVE CHATTANOOGA.

This work has been continued, as heretofore, by the hired-labor system, under Mr. F. T. Hampton, assistant engineer.

With the exception of some delays, caused by high water, good progress was made until the appropriation was exhausted, which occurred about the end of January, 1877.

The boats, tools, and materials were then collected at convenient points and stored for future use under care of suitable watchmen.

As explained in former reports, the object of improving this part of the river is to secure a low-water channel of sufficient depth for steamboats and other craft across the numerous bars and shoals between Chattanooga and Knoxville, and the method of accomplishing this is by excavating rocks and gravel from the worst parts of the shoals and by building rock-dams to contract the width and thus increase the depth of water-way.

The bed and banks of the Tennessee are exceptionally permanent in their nature, the bed being generally of rock at the shoals, and the banks consisting either of rocky bluffs or of earth protected by a dense growth of willows and other vegetation. This gives a remarkably permanent character to the improvements, since the dams have a stable foundation and the excavations in the channel are not liable to fill up. As stated in a former report:

> The absence of ice in this river is another reason why the dams may be considered permanent structures, and gives additional importance to these improvements, since the river can be navigated throughout the year instead of being frozen up for a considerable portion of the time.

The following is a list of the steamboats and their registered tonnage now employed on the Upper Tennessee. Their carrying capacity is estimated to be one-fourth greater than the figures given:

Name.	Tons.	Name.	Tons.
1. J. T. Wilder	185	6. Emory City	65
2. R. M. Bishop	256	7. Lucy Coker	110
3. City of Knoxville	233	8. May Bell	55
4. R. C. Jackson	110	9. Harry Helm	55
5. Ida	110	10. M. A. Gee	30

The following statement shows the quantities and values of different articles of commerce on this river, as far as I have been able to ascertain, for the year ending June 30, 1877:

Articles.		Quantities.	Value.
Corn	bushels	1,250,000	$812,500
Oats	do	65,000	39,000
Wheat	do	185,000	305,250
Bacon	pounds	1,000,000	100,000
Lard	do	650,000	65,000
Hay	do	990,000	7,425
Flour	barrels	1,600	12,800
Wood	cords	2,000	7,000
Coal	tons	500,000	1,625,000
Pig-iron	do	10,000	200,000
Iron-ore	do	13,700	27,400
Saw-logs	feet, (board-measure)	8,000,000	64,000
Tan-bark	cords	1,100	6,600

Besides a large amount of miscellaneous freight.

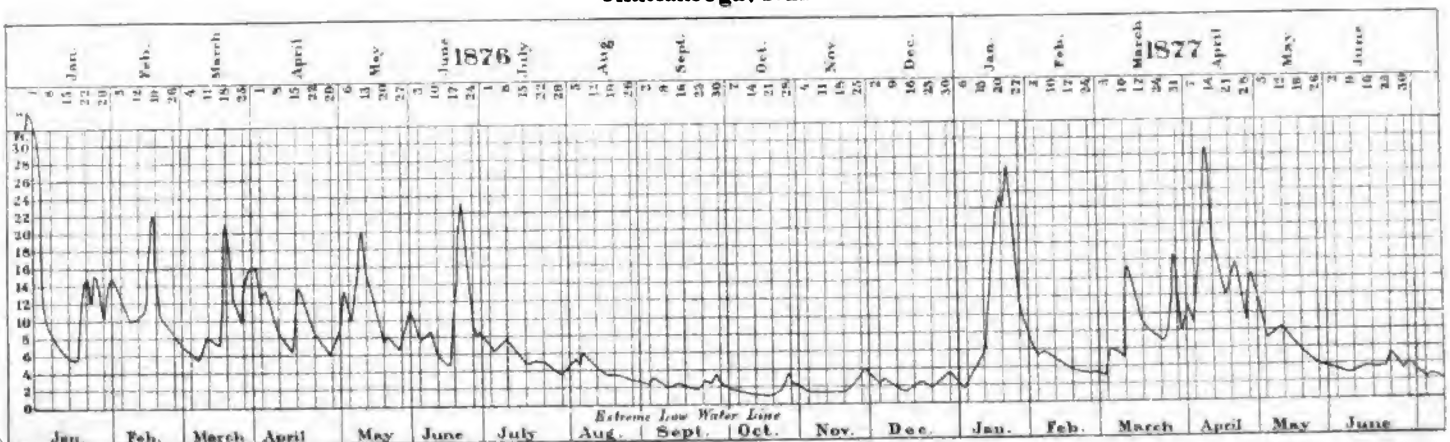
Work during the fiscal year has been directed to the improvement of 16 different obstructions, as follows:

Location.	Cubic yards—		
	Rock quarried.	Rock in dams.	Rock excavated.
Chota Shoals	860	710	[illegible]
Coulter's Shoals	1,200	1,490	[illegible]
Sister's Island	....	....	63
Bustle's Bar	....	....	41
Lenoir's Shoals	....	....	96
Bonder's Shoals	....	....	40
Sweetwater Shoals	275	....	....
Seven Islands	....	200	....
Long Island Shoals	600	500	....
Caney Shoals	....	1,050	....
Turner's Bar	....	....	220
Half-Moon Island	660	690	92
White's Creek Shoals	....	36	....
Hazle Ridge	....	....	[illegible]
Kelly's Shoals	....	600	63
Soddy Shoals	....	470	....
Totals	3,595	5,746	1,4[illegible]

There were also about 105 cubic yards of gravel excavated and 30 snags and a number of overhanging trees removed.

The number of men employed has varied during the working period from 35 to 249.

Water-gauge Tennessee River
at the Bluff,
Chattanooga, Tenn.



It is of course impossible to attain a great degree of economy in work when the funds are exhausted in the middle of the year, since some of the expenses, especially in starting and closing a work, are almost as great when the work continues only six months as they would be for a whole year. In addition, there is liability to damage from floods, and inconvenience to commerce may result in case the work is left in an unfinished state. These difficulties have been obviated as far as they could be foreseen, though in one case, at Chota Shoals, owing to the fact that it became necessary to stop work when the water was but partly turned into the new channel, there is actually less depth of water than when the improvement was begun. It is hoped, therefore, that an early appropriation will be made for completing this improvement and that the amount will be sufficient for an entire year's work.

The record of the gauge kept at the bluffs near this city will be found plotted on a sheet herewith inclosed. As it is brought up from January, 1876, to the end of the fiscal year, it includes two flood-periods of the river following the great flood of 1875. From this it will be seen that the average maximum rise during these two periods was but little more than three-fifths the height of the flood of 1875.

The estimate of cost of improving the Tennessee River *above Chattanooga* was originally assumed to be $175,000. This has of necessity been increased by the construction of additional dams at various points and other contingencies, as explained by Major McFarland in report of the Chief of Engineers, 1874, page 573.

There has been appropriated for this work:

By act of 1871, authorizing the expenditure of $35,000 of the $80,000 appropriated by act of 1870 for improving Tennessee River below Chattanooga...	$35,000
Act of 1872, for improving Tennessee River below Chattanooga	25,000
Act of 1873, for improving Tennessee River below Chattanooga	25,000
Act of 1874, for improving Tennessee River below Chattanooga	25,000
Act of 1875, for improving Tennessee River below Chattanooga	40,000
Act of 1876, for improving Tennessee River below Chattanooga	15,000
	165,000

The above amount has been expended, excepting a balance of $167.28, which is needed to pay outstanding liabilities, consisting of pay for services due laborers and remaining unpaid.

Money statement.

July 1, 1876, amount available	$7,862 01	
Amount appropriated by act approved August 14, 1876......	15,000 00	
		$22,862 01
July 1, 1877, amount expended during fiscal year.............	22,694 73	
July 1, 1877, outstanding liabilities..............................	167 28	
		22,862 01
Amount (estimated) required for completion of existing project...........		60,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		35,000 00

R 2.

IMPROVEMENT OF TENNESSEE RIVER BELOW CHATTANOOGA.

Work on this portion of the river has been confined to Muscle Shoals and Colbert's Shoals, and to examinations and surveys of certain other parts of the river.

A.—ELK RIVER SHOALS.

These shoals are at the upper end of the chain of obstructions known as *Muscle Shoals* and their improvement has been contemplated and estimated for in all schemes for the improvement of the Tennessee River.

The usual plan recommended has been to extend the Muscle Shoals canal along the north side of the river and around these Shoals to a point near the upper end of Brown's Island. (See map herewith.) The estimate for this is $1,115,000. It will be noticed that this line crosses the mouth of Elk River, a stream but little known, but which drains more than 2,000 square miles of country, or about the area of the whole State of Delaware. To cross this stream, except by an aqueduct, would be an extremely dangerous experiment, and would require a guard lock below the river high enough to reach above the highest floods in either Elk River or in the Tennessee.

With a view to avoiding this difficulty, and of taking advantage of some 5 miles of deep water in the Tennessee above the mouth of the old canal, a resurvey of the south shore of the river from Brown's Island to Lamb's Ferry was authorized by the Chief of Engineers, and was completed in January last by Mr. Paul Le Hardy, whose report is appended. From this it appears perfectly feasible to take the south side of the river, and that the cost will be greatly reduced thereby. His estimate, which appears liberal, and includes 25 per cent. for contingencies, is $736,249, or $378,750 less than the lowest estimate for the canal on the north side of the river.

No work has yet been done on these shoals, but as they form an essential part of the Muscle Shoals obstructions, it is desirable that work on them should be begun as soon as possible, in order that it may be completed at the same time as the work on the Muscle Shoals proper, and the estimate of funds required for the next fiscal year has been made with that object in view.

B.—MUSCLE SHOALS CANAL.

This work is a continuation of the enlargement and rebuilding of the old canal around Big Muscle Shoals.

The work has been carried on under six different contracts, all but one of which have been completed and closed during the year.

The following tables show the quantities of work done under each contract during the year:

Contractors.	Section.	Date of contract.	Earth excavation.	Earth embankment.	Rock excavation.	Slope wall.	Grubbing and clearing.	Cost
		1875.	C. yds.	C. yds.	C. yds.	C. yds.	Acres.	
T. Ford & Co.	1	Dec. 13	4,188	2,113	18,499	857	3.08	[illegible]
Foster, Wiehl & Jackson	2	Dec. 13	9,139	7,079	8,207	178	1.340	[illegible]
M. G. Kennedy	3	Dec. 13	10,074	14,619	5,246	1,312	1.522	[illegible]
Do	4	Dec. 13	21,567	6,308	3,304	417	9.13	[illegible]
Do	5	Dec. 13	15,968	12,817	16	672	.80	[illegible]
Do	6	Dec. 13	2,651	9,177	....	....	2.40	[illegible]
Rice & Reid	7	Dec. 13	1,806	1,283	....	....	1.70	[illegible]
Total	....	....	65,393	53,396	35,272	3,436	45.73	[illegible]

Contractors.	Lock.	Date of contract.	Earth excavation.	Rock excavation.	Cut-stone masonry.	Rubble masonry.	Concrete.	Removal of old locks.	Cost.
		1876.	C. yds.	C. yds.	C. yds.	C. yds.	C. yds.	C. yds.	
George Williams....	2	Oct. 14	1,370	3,202	....	....	....	....	$3,544 50
Do	3	Mar. 31	12,527	1,850	620.7	1,805.4	39.9	1,358.1	34,169 90
Do	4	Mar. 31	6,393	2,123	1,019.8	3,752.8	....	2,125.4	52,154 88
Total..........	....	....	20,290	7,175	1,640.5	5,558.2	39.9	3,483.5	89,869 28

Of the stone removed from the old locks, $10\frac{74}{100}$ cubic yards have been used as "facing," and $795\frac{12}{100}$ cubic yards have been used as "backing," in the construction of new locks 3 and 4, and for which the contractor has paid the United States the sum of $316.60, in accordance with the terms of his contract.

The contract of Mr. George Williams for the building of locks 3 and 4 was to have been completed by the 1st of July last, but he has applied for and received an extension of time until the 1st of October next.

During the year two assistant engineers, Messrs. James C. Long and William M. Gordon, each with a small engineering party, have been stationed on the line of the canal to give grades, make cross sections, inspect materials, and see that the work was executed in accordance with the specifications of the contracts.

These engineering parties have also made additional surveys of certain parts of the line with a view to the future prosecution of the work, and have superintended small working-parties that have been employed from time to time to repair and protect portions of the work from damage by rains and floods.

Under the contracts for section-work about 8 miles of the canal-trunk have been completed, with the exception of dams at waste-wiers at the crossings of several creeks which intersect the line of the canal. These dams will not be put in until the locks are all built and the rest of the canal is nearly ready for use.

Under the lock-contracts the foundation-pits of three locks have been excavated, a large quantity of stone has been quarried and cut, and the walls of two of the locks were about two-thirds completed at the end of the fiscal year.

The locks are 300 feet between miter-sills, 60 feet wide in the chamber, and from 5 to 12 feet lift, the walls being of substantial cut stone and rubble masonry 5 feet thick at top and from 9 to 11 at base, with suitable buttresses, culverts, and wing-walls. From the best information we can obtain by test-pits the indications are that all the locks can be securely founded upon solid rock.

Owing to the great width of the locks, as compared with the depth of water, the width in the upper bay being ten times the depth, the upper gates, if built on the old miter plan, will be considerably out of proportion, and will require recesses some 36 feet long, which lengthens out the side walls of the lock by about that distance. As an improvement on this arrangement, Lieutenant Marshall, Corps of Engineers, has proposed a form of drop-gate, which appears well worthy of trial, and if it can be applied to the locks yet to be built will save some 4,000 cubic yards of masonry, besides a considerable saving in the cost of the gates themselves. Lieutenant Marshall also proposes a modified form of drop-gate for the lower gates, which would also effect quite a saving in the cost

of the locks, though their feasibility is not as apparent as in the case of the upper gates.

On the 15th of May last proposals were opened at this office for the building of 5 new locks, Nos. 6, 7, 8, 9, and 10.

The abstract appended shows the proposals received, from which it will be seen that several responsible parties offer to build these 5 locks for less than $200,000, or an average of $40,000 each, which must be considered as highly advantageous terms for the Government. No award was made up to the close of the fiscal year, though it is hoped the contracts will be made in time to allow the contractors to make at least a good beginning this season.

The old canal had 17 locks, of about 5 feet lift each, but it has been found much cheaper in first cost, and will be still more economical in working, to use a smaller number of locks with a greater lift. This makes a slight increase in the quantity of embankment, but the cost of this is but a fraction of the cost saved in masonry, lock-gates, &c.

But 10 locks are required, the lifts varying from 5 to 12 feet, as shown in the following table:

Locks on Muscle Shoals Canal.

Number.		Number of old locks replaced.	Lift.
	1	1	Guard-lock.
Under contract	2	2	6 feet.
	3	3, 4, and 5	12 feet.
	4	6 and 7	10 feet.
	5	8 and 9	10 feet.
Proposals received	6	10	5 feet.
	7	11 and 12	10 feet.
	8	13 and 14	12 feet.
	9	15	10 feet.
	10	16 and 17	10 feet.
		Total lift	85 feet.

From this table it will be seen that in case the proposals received are accepted all the locks will be under contract but one guard-lock and one lift-lock.

Among the creeks crossing the line of the canal, which are generally small, is one of considerable size called Shoal Creek, which drains more than 500 square miles of territory, or nearly one-half the area of the State of Rhode Island.

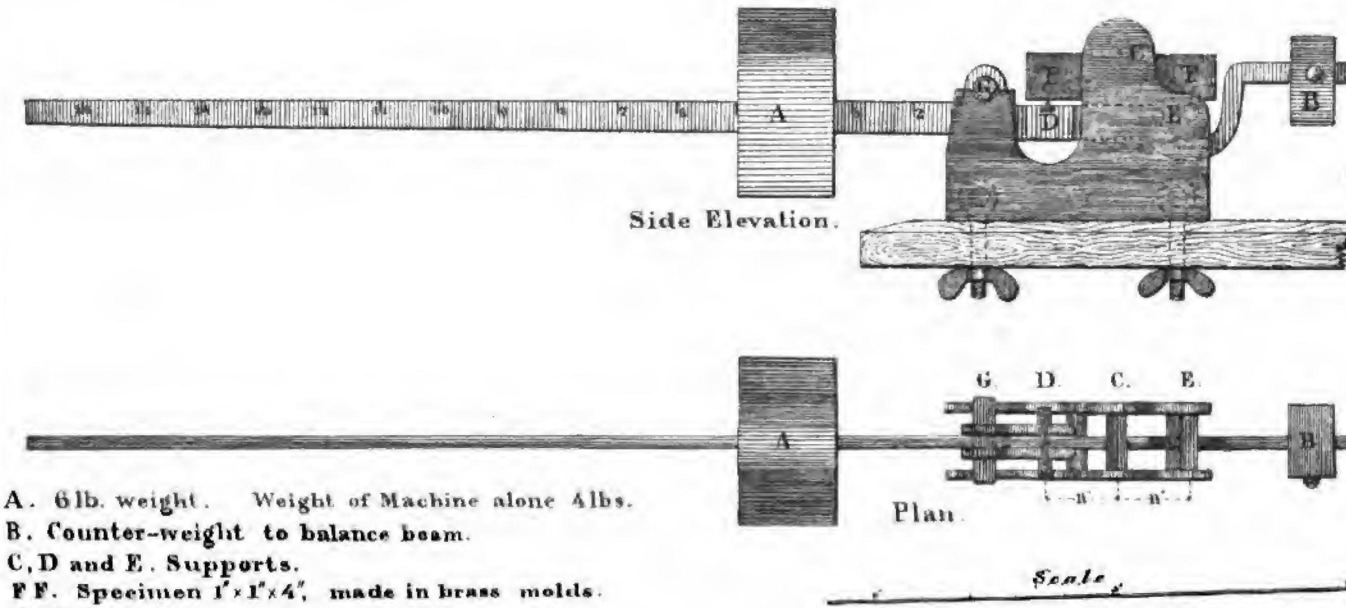
In the re arrangement of locks it was found practicable to provide for carrying the trunk of the canal over this stream on an aqueduct, and the smooth, rocky bed of the stream was found also favorable to this plan, which will enable us to get rid of what must otherwise prove a very troublesome customer during its flood-stages. From preliminary estimates it has been found that this aqueduct can be built with stone piers and a wooden or iron trunk for from $40,000 to $80,000, according to the material used. I find from a report of the Board of Internal Improvements in 1832 that they recommended this very plan for crossing Shoal Creek in the original project for the canal. I am also informed that the substitution of a dam and open crossing of the creek for an aqueduct, which was probably done for want of funds, was one of the causes which led to the disabling and final disuse of the old canal.

The low prices for which contractors seem anxious to do work and the very considerable quantities of masonry saved by diminishing the number of locks, as already explained, will probably bring the entire cost of this work far within the original estimate, and for the same rea-

Machine for testing Cement.

Designed by Capt. W. R. King, U. S. Engrs.

1876.



A. 6 lb. weight. Weight of Machine alone 4 lbs.

B. Counter-weight to balance beam.

C, D and E. Supports.

F F. Specimen 1″ × 1″ × 4″, made in brass molds.

G. Fulcrum.

son the time required to complete the work can be very much shortened, provided, of course, that the appropriation is large enough to carry on the work to advantage.

In testing cements offered by the contractor and manufacturers, a large number of experiments have been made, which will be useful in connection with my future work in this vicinity requiring hydraulic cement of good quality. In addition to the tests made with a large machine and specimens 1½ and 2 inches square, a small machine has been constructed with special reference to testing samples from each barrel delivered at the work. These samples were mixed in a uniform manner and pressed in brass molds, forming specimens 1 inch square and 4 inches long. These specimens were allowed one day to dry in the shade and were then immersed for six days in fresh water. They were then broken by a steady pressure in the machine, the points of support being 3 inches apart, with a bearing directly over the middle. The machine worked admirably, and its bulk and cost are so small as to lead me to think it may be found useful elsewhere. I therefore inclose a sketch of this little machine, the details of which will be understood without further description.

Some questions having arisen as to the quality of the stone in certain quarries in the vicinity of the canal, specimens from several quarries were sent to Capt. Alexander Mackenzie, Corps of Engineers, at Louisville, Ky., who had facilities for testing their qualities, and who has kindly furnished a report on the same.

In order to facilitate the copying of drawings and to furnish means of making an accurate representation of the work from time to time, as it progresses, authority was obtained from the Chief of Engineers to purchase a camera and other necessary apparatus and materials for taking photographic views, and Mr. Julius Shutting was detailed to use the apparatus, in addition to his regular duties as draughtsman. This he has done in a very satisfactory manner, and the photographs furnish not only a satisfactory index to the progress of the work, but, being taken from known points and in specified directions, they can at any time be repeated, and will furnish unmistakable records, which can be referred to at any future time to settle doubtful questions that may arise relative to the condition of the work on a given date or to changes that have taken place. They have already proved quite valuable in that respect, and I venture to forward with this report 7 of them, which are characteristic views of the work and its surroundings at the end of the fiscal year, in the hope that by means of Woodbury's process or otherwise it may be practicable to have them printed with this report.

C.—LITTLE MUSCLE SHOALS.

This obstruction, which lies between Big Muscle Shoals and Florence, Ala., has a total fall of about 22 feet in a distance of 6 miles, and an estimate has been made for improving it by means of locks and dams, at a cost of $902,500. (Report of the Chief of Engineers, 1872, page 501.)

From a personal examination of this obstruction, I am satisfied that it can be made navigable at all stages of the water by a system of improvement similar to that applied on the Upper Tennessee and the Cumberland. The conformation of the river at that point, especially in regard to uniform slope and the location of islands, is such that the requisite depth of water can easily be obtained, and the velocity of the current will undoubtedly be less than at several other points on the river.

Last spring a small steamboat ascended this shoal, with barges in tow, until almost the low-water season, and was only stopped by want of water.

As a small fraction, say one-tenth, of the cost of building locks on these shoals will give as great a depth of water on them as can be obtained throughout a considerable portion of the river both above and below Muscle Shoals, (without an expenditure of money far greater than has yet been contemplated,) and as the improvement in this way can be supplemented, if found desirable, either by wire-rope towage, as suggested for Smith's Shoals on the Cumberland, or by locks and dams, without increasing the cost of the whole work above what it would cost to adopt the more expensive plan at first, since nearly all the provisions for deepening the channel would be required in either case, it appears decidedly better to begin with the cheaper and more expeditious plan of improvement.

It is believed that all the work that will be required on these shoals can be completed in one year, and as this would allow boats to run up to the mouth of the canal at all times, it would greatly facilitate delivery of supplies and materials needed for that work.

See maps of Muscle Shoals, herewith.

D.—COLBERT SHOALS.

These shoals form the most serious obstruction to navigation on the Tennessee River below the Muscle Shoals. Considerable work has been done on them from time to time, and it was the intention to complete their improvement last season, but owing to unusually high water, and other causes of delay, it was found impracticable to do so.

There were, during the working season, 167½ cubic yards of rock excavated from the channel, and 1,055 cubic yards of rock quarried, and 2,198 cubic yards placed in dams. Work was suspended on the 15th of November, 1876, and was not recommenced before the close of the fiscal year, on account of the continued high water. It is now (August 6) making good progress; and, with an average season for channel-work, will be completed before the 1st of January next.

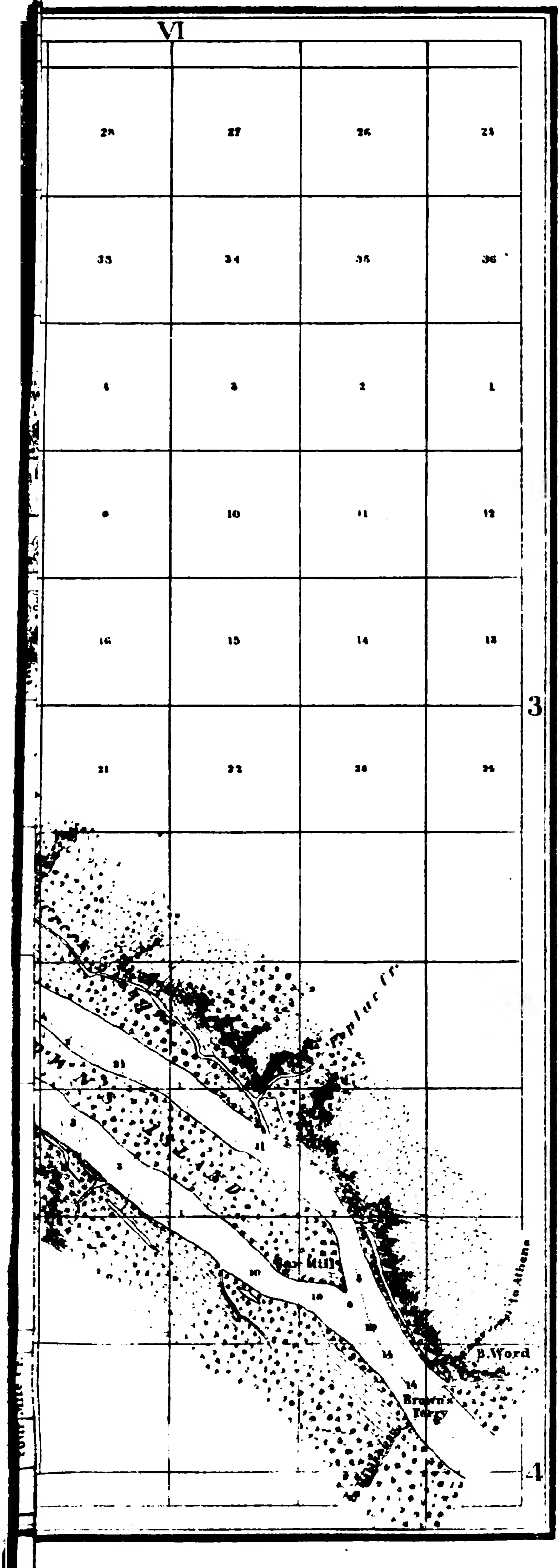
The Tennessee River is, I believe, situated in the collection-district of New Orleans. The amount of revenue from customs collected from the nearest port of entry (New Orleans) has not been ascertained, as it will be embraced in the report of the engineer officer in charge of river and harbor improvements at that port.

The original estimate of the cost of improving the Tennessee River, *below Chattanooga*, is as follows:

Estimate of Maj. G. Weitzel "to improve the river from its mouth to Florence, Ala., and from Decatur, Ala., to Chattanooga, Tenn." (Report Chief of Engineers, 1870, page 389)	$130,000
Estimate of Major McFarland "for improving Muscle Shoals," (Report Chief of Engineers, 1873, page 544)	4,003,000
Original estimate of entire work	4,133,000

From the general appropriations, for "repairs, &c., of public works on rivers and harbors," &c., there has been appropriated for this work:

An allotment in 1868 of	$35,000
An allotment in 1869 of	40,500


VI
3
Poplar Cr.
Saw Mill
to Athens
B. Word
Brown's Ferry
4

By special appropriations:

Act of 1870	$45,000
Act of 1872	50,000
Act of 1873	100,000
Act of 1874	100,000
Act of 1875	360,000
Act of 1876	255,000
	1,035,500

At the close of the fiscal year, $603,829.04 of the above amount had been expended. Balance to be appropriated, $3,097,500.

Probably not more than two-thirds of this amount will be required, in view of the reductions made and to be made, as explained in the foregoing report.

Money statement.

July 1, 1876, amount available	$359,935 92	
Amount appropriated by act approved August 14, 1876	255,000 00	
		$614,935 92
July 1, 1877, amount expended during fiscal year	183,264 96	
July 1, 1877, outstanding liabilities	10,474 64	
		193,739 60
July 1, 1877, amount available		421,196 32
Amount (estimated) required for completion of existing project		3,097,500 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		745,000 00

Abstract of proposals for constructing locks of Muscle Shoals Canal, Tennessee River, opened May 15, 1877, by Captain W. R. King, Corps of Engineers.

Number of bid.	Names and residences of bidders.	Number of lock bid for.	Excavation per cubic yard.			Masonry per cubic yard.				Allowances per cubic yard.			Total less the allowances.
			Earth.	Solid rock.	Old locks.	Cut stone.	Rock face.	Rubble.	Concrete.	Stone from old locks used as cut stone.	Stone from old locks used as rock face.	Stone from old locks used as rubble.	
1	George Williams, Keokuk, Iowa	Lock 6	$0 30	$2 00	$1 00	$20 00	$14 00	$9 00	$7 00	$14 00	$10 00	$5 00	$32, 230
		Lock 7	30	2 00	1 00	20 00	14 00	9 00	7 00	14 00	10 00	5 00	51, 200
		Lock 8	50	3 00	1 00	24 00	16 00	12 00	7 00	14 00	12 00	5 00	68, 350
		Lock 9	50	4 00	....	22 00	16 00	10 00	7 00	....	....	......	46, 750
		Lock 10	60	4 00	1 00	24 00	16 00	12 00	7 00	18, 00	12 00	6 00	72, 950
		Entire work	40	2 50	1 00	22 00	16 00	10 00	7 00	15 00	10 00	5 00	255, 030
2	Walter Doty, Fort Edward, New York	Lock 6	50	2 00	1 00	16 00	15 00	10 00	7 00	1 50	1 50	1 00	35, 905
		Lock 7	50	2 00	1 00	17 00	16 00	10 00	7 00	1 50	1 50	1 00	57, 750
		Lock 8	50	2 00	1 00	18 00	17 00	10 00	7 00	1 50	1 50	1 00	60, 425
		Lock 9	50	2 00	....	18 00	17 00	10 00	7 00	....	....	......	37, 650
		Lock 10	60	3 00	2 00	20 00	19 00	12 00	8 00	1 50	1 50	1 00	75, 600
		Entire work	50	2 90	1 00	18 00	17 00	9 50	6 00	1 50	1 50	1 00	248, 980
3	Hugh Carlisle, Guntersville, Alabama	Lock 6	34	1 19	85	13 90	10 10	5 90	5 90	3 00	3 00	1 00	24, 789
		Lock 7	34	1 19	85	13 90	10 10	5 90	5 90	3 00	3 00	1 00	37, 795
		Lock 8	49	1 19	85	15 90	13 00	7 90	7 90	3 00	3 00	1 00	49, 323
		Lock 9	49	1 19	....	15 90	13 00	7 90	7 90	....	....	......	29, 710
		Lock 10	1 00	2 00	85	25 00	20 00	14 90	11 00	7 00	7 00	7 00	80, 900
4	S. N. Kimball, Mobile, Alabama	Lock 6	30	2 00	1 00	15 00	12 50	6 50	6 00	5 00	4 00	2 00	27, 000
		Lock 7	40	1 50	90	14 50	13 00	6 50	6 00	5 00	4 00	2 00	41, 880
		Lock 8	25	1 00	75	13 00	11 00	6 00	6 00	5 00	4 00	2 00	37, 825
		Lock 9	25	1 00	....	13 00	11 00	6 00	6 00	....	....	......	23, 000
		Lock 10	40	1 75	90	14 50	13 00	6 50	6 00	5 00	4 00	2 00	44, 450
		Entire work	35	1 25	1 00	13 50	10 00	6 00	6 00	5 00	4 00	2 00	164, 505
5	Boyle & Condon, Cincinnati, Ohio	Lock 6	25	2 25	2 00	16 00	13 00	9 00	6 00	7 00	7 00	3 50	31, 090
		Lock 7	40	1 75	2 00	16 00	13 00	9 00	6 00	7 00	7 00	3 00	51, 375
		Lock 8	35	2 00	2 00	18 00	15 00	11 00	7 00	7 00	7 00	3 00	62, 225
		Lock 9	35	4 00	....	18 00	16 00	11 00	7 00	....	....	......	46, 000
		Lock 10	1, 00	3 00	2 00	28 00	23 00	19 00	7 00	7 00	7 00	3 00	101, 100
6	Archibald McArthur, Chicago, Illinois	Lock 6	50	2 50	1 00	16 00	13 00	10 00	6 00	2 00	2 00	2 00	34, 890
		Lock 7	50	2 50	1 00	16 00	13 00	10 00	6 00	2 00	2 00	2 00	56, 050
		Lock 8	50	2 50	1 00	16 00	13 00	10 00	6 00	2 00	2 00	2 00	56, 900
		Lock 9	50	2 50	....	17 00	13 00	10 00	6 00	....	....	......	37, 850
		Lock 10	65	3 25	1 00	21 00	17 00	13 00	7 00	2 00	2 00	2 00	76, 425
		Entire work	50	2 75	1 00	16 25	13 25	10 25	6 00	2 00	2 00	2 00	252, 908. 50

7	Ward, Ingerson & Allen, Worcester, Massachusetts	Lock 6	50	2 50	1 00	15 00	14 00	6 00	7 00	5 00	4 00	2 00	29, 430
		Lock 7	50	1 75	1 00	15 00	14 50	6 00	7 00	5 00	4 00	2 00	43, 630
		Lock 8	60	2 00	1 00	15 00	14 50	6 00	7 00	5 00	4 00	2 00	44, 325
		Lock 9	50	1 75		15 00	14 50	6 00	7 00				29, 250
		Lock 10	60	2 00	1 00	15 00	14 50	6 00	7 00	5 00	4 00	2 00	47, 475
		Entire work	50	1 75	1 00	15 00	14 00	6 00	7 00	5 00	4 00	2 00	190, 430
8	Lewis H. Ferrell, Louisville, Kentucky	Lock 6	40	1 50	2 00	14 00	13 00	6 00	4 00	75	50	25	28, 305
		Lock 7	40	1 50	2 00	14 00	13 00	6 00	4 00	75	50	25	43, 650
		Lock 8	40	1 50	2 00	14 00	13 00	7 00	4 00	75	50	25	46, 650
		Lock 9	40	2 00		15 00	14 00	7 00	4 00				30, 250
		Lock 10	1 00	2 00	2 00	16 00	15 00	8 00	4 00	75	50	25	59, 575
9	Thomas Rogers, Saint Louis, Mo	Entire work	56	2 06	1 25	21 40	15 55	11 65	8 00	1 50	1 25	1 00	287, 285
10	Wells & Timberman, Keokuk, Iowa	Lock 6	40	2 00	1 50	20 00	19 00	12 00	2 50	4 00	3 00	1 00	40, 680
		Lock 7	40	2 00	1 50	20 00	19 00	12 00	2 50	4 00	3 00	1 00	64, 625
		Lock 8	50	2 50	2 00	22 00	26 00	13 00	3 00	5 00	4 00	1 00	74, 710
		Lock 9	60	3 50		23 00	22 00	13 00	3 00				50, 600
		Lock 10	60	3 00	2 50	28 00	27 00	18 00	3 00	5 00	4 00	1 00	98, 200
11	Satterlee, Cameron & Penny, New York City	Lock 6	22	1 30	1 00	14 00	13 30	6 20	4 50	2 00	2 00	50	25, 541
		Lock 7	22	1 30	85	14 00	13 00	6 20	4 50	1 00	1 00	1 00	39, 755
		Lock 8	22	1 30	85	15 00	13 00	6 20	4 50	1 00	1 00	1 00	41, 830
		Lock 9	22	1 30		15 00	13 00	6 20	4 50				25, 255
		Lock 10	30	3 60	1 50	17 00	14 30	7 30	5 80	1 00	1 00	1 00	57, 865
		Entire work	22	2 00	85	16 00	13 40	6 20	4 50	1 00	1 00	1 00	188, 038
12	James E. Slaughter, Mobile, Ala	Lock 6	20	1 00	75	12 00	10 00	6 00	5 00	6 00	5 00	2 50	21, 510
		Lock 7	20	1 00	75	12 00	10 00	6 00	5 00	6 00	5 00	2 50	33, 550
		Lock 8	30	1 50	1 00	13 00	11 50	6 50	5 50	6 00	5 00	2 50	40, 275
		Lock 9	20	1 00		12 00	10 00	6 00	5 00				21, 850
		Lock 10	30	1 25	1 00	13 00	11 50	6 50	5 50	6 00	5 00	2 50	39, 400
		Entire work	30	1 25	75	12 00	10 00	6 00	5 00	6 00	5 00	2 50	153, 360
13	Huston, Neely & Co., Chattanooga, Tenn	Lock 6	50	1 75	1 25	14 50	14 00	8 50	6 00	4 00	3 00	2 00	32, 265
		Lock 7	50	1 75	1 25	15 00	14 50	8 50	6 00	4 00	3 00	2 00	50, 400
		Lock 8	50	2 50	1 25	16 00	15 75	10 00	6 00	4 00	3 00	2 00	58, 287. 50
		Lock 9	50	2 00		16 00	15 75	10 00	6 00				36, 325
		Lock 10	1 20	4 50	1 25	17 00	16 00	10 00	6 00	4 00	3 00	2 00	75, 100
		Locks 8, 9, and 10	85	3 00	1 25	16 00	15 50	10 00	6 00	6 00	4 00	2 00	166, 450
14	N. S. Eaves & Co., Cartersville, Ga	Lock 6	50	1 75	1 00	18 00	16 00	8 00	7 00	2 00	75	50	34, 785
		Lock 7	50	1 75	1 00	19 00	17 00	8 00	7 00	2 00	1 00	1 00	53, 775
15	John B. Doyle, Cohoes, N. Y	Locks 9 and 10	30	2 15	1 50	13 50	13 50	7 50	7 30	6 25	6 25	1 25	79, 805
16	S. P. Myer & John Hay, Louisville, Ky	Lock 6	27	1 25	2 75	19 00	15 00	9 00	7 50	7 00	6 00	4 50	34, 295
		Lock 7	27	1 40	2 75	19 00	16 00	9 00	7 50	7 00	6 00	4 50	54, 810
		Lock 8	28	1 50	2 75	21 00	16 00	9 00	7 50	7 00	6 00	4 50	59, 780
		Lock 9	30	2 50		20 00	17 00	9 50	7 50				34, 775
		Lock 10	25	4 00	4 00	26 00	20 00	11 00	7 50	7 00	6 00	4 50	79, 750
17	C. Ford & Co., Keokuk, Iowa	Lock 6	50	2 50	2 25	16 50	14 25	9 50	5 50	8 50	3 20	3 00	35, 710
		Lock 7	50	2 00	2 25	16 50	14 00	10 00	5 50	8 00	3 00	3 00	57, 175
		Lock 8	50	2 00	2 00	16 50	14 20	9 50	5 50	8 50	3 00	3 50	56, 440
		Lock 9	50	2 00		16 70	14 20	9 50	5 50				35, 280
		Lock 10	90	3 50	3 00	22 00	19 00	12 00	7 00	5 00	3 00	3 00	81, 750
18	Hervey S. Dale, Chicago, Ill	Lock 6	35	1 45	1 00	15 00	14 00	8 00	6 00	2 50	2 50	1 50	30, 155
		Lock 7	35	1 45	1 00	15 00	14 00	8 00	6 00	2 50	2 50	1 50	46, 900
		Lock 8	35	1 45	1 00	15 00	14 00	8 00	6 00	2 50	2 50	1 50	48, 740
		Lock 9	35	2 00		15 00	14 00	8 00	6 00				31, 900

Abstract of proposals for constructing locks of Muscle Shoals Canal, Tennessee River, &c.—Continued.

Number of bid.	Names and residences of bidders.	Number of lock bid for.	Excavation per cubic yard.			Masonry per cubic yard.				Allowances per cubic yard.			Total, less the allowances.
			Earth.	Solid rock.	Old locks.	Cut stone.	Rock face.	Rubble.	Concrete.	Stone from old locks used as cut stone.	Stone from old locks used as rock face.	Stone from old locks used as rubble.	
18	Hervey S. Dale, Chicago, Ill	Lock 10	65	2 00	1 00	18 00	17 00	9 00	6 00	2 50	2 50	1 50	59,025
		Entire work	35	1 47	1 00	15 00	14 00	6 25	6 00	3 50	3 50	1 50	184,359
	Donahoe & Shields, New York City*	Locks 6 and 7	......	......	......	......	......	......	......	......	......	......	......
	John Malloy & Co., Chattanooga, Tenn.†	Locks 6 and 7	......	......	......	......	......	......	......	......	......	......	......

* Received too late. Opened May 16, 1877. Informal.

† Received too late. Opened May 16, 1877. Informal.

REPORT OF MR PAUL LE HARDY, ASSISTANT ENGINEER.

CHATTANOOGA, TENN., *January* 29, 1877.

CAPTAIN: I beg to submit herewith my report on the examination of the Tennessee River from Guntersville, Ala., to Brown's Ferry, and on the resurvey of the Elk River Shoals.

In accordance with instructions received from you, dated October 23, 1876, I proceeded to Guntersville to take charge of the survey-boats left there by Mr. W. G. Williamson, assistant engineer.

Rainy weather having set in just before my arrival at Guntersville, I was anxious to reach the Elk River Shoals before the river became too high and muddy to permit of a satisfactory examination there. I therefore made hurried examinations of the various obstructions between Guntersville and Brown's Ferry without stopping the large boats; for, owing to the very low stage of the river, there was very little current, and the small number of men we could accommodate on the boats made our progress slow enough.

At Guntersville the river is about 30 feet deep; this depth gradually decreases as we approach

BEARD'S REEF, 2 MILES BELOW GUNTERSVILLE.

This consists of a ledge of limestone running straight across the river from the south bank to within 250 feet of the north bank. At low water there is a depth of only 1'.8 in this channel, while the reef is almost bare.

About 400 feet below this "chute" is a broad gravel-bar, extending from the north bank half-way across the river, compelling boats to turn immediately below the reef, and run to the south side of the river.

Three-quarters of a mile below this reef,

BEARD'S BLUFF,

a high limestone ridge, ends abruptly at the water's edge, and causes the river to take a northerly course for a couple of miles. The water is over 10 feet deep opposite this bluff, and remains deep down to the

MOUTH OF FLINT, 18 MILES BELOW GUNTERSVILLE.

There are 2 snags in the channel opposite, or a little below the mouth of Flint River. The water is from 4 to 10 feet deep in the channel, which at this point is on the north side, but turns to the south side from just below the mouth of the Flint.

From this point there is deep water to

COBB'S ISLAND,

which begins about 23 miles below Guntersville. The main channel is on the south side, and the least depth found is about 4 feet until near the foot of this island, which is about 3 miles long, where a reef extends across the channel, and there is not over 2 feet of water on it at the lowest stage. As the current is not very strong, gravel and some drift form a bar extending a few hundred feet below the reef.

One mile below this reef is Whitesburg, a landing some 9 miles south of Huntsville, and about 27 miles below Guntersville.

Three-quarters of a mile below Whitesburg is a reef or broad, shallow, limestone bar, on which there is at low water only about 2 feet depth, the "chute" being near the middle of the river; fall very light.

From here the river becomes deep again for a long distance.

LIMESTONE SHOALS,

the next obstruction, is about 55 miles below Guntersville. The river here averages about 2,000 feet in width, bottom very even, of solid limestone.

A reef extends across the river about ¾ of a mile below the mouth of Limestone Creek, over which there is 2½ feet at low water, with shallow water for about 100 yards above and below the reef.

The steamboat-channel is from 200 to 300 feet from the north bank, and a dangerous rock stands on the reef just in the channel.

From Limestone Shoals to Decatur, about 6 miles, there is good water without obstructions.

At Decatur the "draw" in the Memphis and Charleston Railroad bridge gives a

channel of about 60 feet only, and is too close to the shore to allow an easy passage to steamboats.

From Decatur to Brown's Ferry, a distance of 12 miles, there are no obstructions.

To improve the river at the various points already mentioned, I would propose the following plans, viz:

At *Beard's Reef*, a wing-dam thrown across the stream just below the reef from the south bank to the outer edge of the boat-chute probably will give depth enough in the channel; another dam below to prevent the water thus gained from being lost over the gravel-bar.

1,500 linear feet of riprap dams, at $10 per linear foot $15,000

At *mouth of Flint*, the removal of 2 snags will leave the channel clear of obstructions, with a depth of from 4 to 10 feet at low water.

Removing 2 snags, at $25 each $50

At *Cobb's Island*, a wing-dam about 600 feet long, will, it is believed, give the requisite 4 feet depth at low water.

Opposite, or a little below the head of Cobb's Island, stone could be had from Coffee's Bluff.

600 linear feet of riprap dams, at $10 per linear foot $6,000

At *Whitesburg Shoal*, as this place is shallow for some distance, excavating a channel would be too expensive, and the fall being very light, perhaps the best way to overcome the shallow water is to build 2 wing-dams from the opposite shores, leaving a channel where there is most water now.

1,500 linear feet of riprap dams, at $10 per linear foot $15,000

At *Limestone Shoals*, a dam along the reef from the south bank to the boat-channel, near the north bank, and a retaining-dam of about 100 yards, would make the channel available to boats drawing 3 feet of water.

2,000 linear feet of riprap dams, at $10 per linear foot $20,000

ELK RIVER SHOALS.

The survey of this portion of the Tennessee River was begun on the south bank, a little above the head of Brown's Island. Search was made for some station of the survey of 1871 as a point to start from, but none could be found; the original line having been run in fields, the stakes were all plowed up. Bench-marks had been mutilated, and the elevations completely effaced by time. A line of levels was started with an assumed elevation of 500 feet above tide.

Frequent triangulation was made to ascertain the width of the channel, and especially to locate lines of soundings.

Down as far as station 59+67 the depth of water ranged from 4 to 10 feet. Frequently this depth could be found right close to the banks.

Below station 59+67 commences a series of reefs extending across the channel and down as far as station 94; least depth of water in boat-chute is 1.8 feet at lowest stage, but the chute is so crooked as to be entirely unavailable at low water for other than light flat-boats.

It is therefore deemed necessary to extend a riprap dam from the island toward the south bank, and a retaining-dam down to the foot of this shoal, thus making a channel along the south bank of the river. Some rock excavation will be necessary to remove the crests of the reefs.

The fall on this shoal is 0.89 foot in 3,400 feet, and will be no impediment to navigation.

From station 94 to station 120, there is from 3 to 4 feet of water in the channel.

Opposite station 120 begins another series of reefs, extending down as far as station 145, with very nearly 4 feet in the channel between the reefs. As the best water is in the middle of the river, I propose to raise the water by building at the foot of the shoal 2 wing-dams from both banks toward the chute, leaving an opening about 400 feet wide.

Some excavation will also be necessary to clear the channel of some projecting rocks and a portion of the upper reef.

The fall on this shoal is 0.64 foot in 2,500 feet.

From station 145 to the foot of Brown's Island the depth of water is from 4 to over 10 feet. But the river is shallow half-way from the foot of the island to the south shore, and remains shallow down to Milton's Bluff, a mile and a half below.

A series of reefs, with shallow water between them, begins a little below the foot of Brown's Island, and continues down to Milton's Bluff. The river here becomes very wide, and the fall is greater than on the previous shoals.

It will be necessary to confine the water of the south side of Brown's Island into a narrower channel. A dam must be built from the foot of the island, almost directly down stream to a point opposite Wild-Goose Towhead, about 800 feet to the right of it, and from here a stronger dam to the towhead. This is to prevent drift-wood from accumulating in the channel as it narrows below. From the towhead a retaining-dam gradually

approaching the south shore down to station 314, where the channel would be about 300 feet wide.

The fall from the foot of Brown's Island to eddy water, opposite the foot of Milton's Bluff, is 3.12 feet in 7,000 feet.

Just below Milton's Bluff is a large group of "Towheads," so closely united by piles of drift-wood that they are gradually forming a large island, and would soon form part of the main-land were it not that the narrow channel, now open, is wanted to form a link in the proposed improvement of these shoals.

It will be necessary to enlarge a portion of the channel existing between these tow-heads and the main shore, and turn it into a canal by building a large embankment in continuation of the system of dams, from the foot of Brown's Island. Material for this embankment is to be found in the portions of the towheads that are to be removed, and from the bluffs, which along this channel terminate abruptly near the water's edge.

This canal would extend to what is known as Gilchrist's Old Mill, where the group of towheads ceases.

The fall from Milton's Bluff to the top of the fall at the old mill-dam is 4.42 feet, and to the foot of the fall it is 5.75 feet in 6,000 feet.

In order to overcome this fall, it will be necessary to establish a lock where the old mill was. By giving this lock 12 feet lift, we can have slack-water up to the head of Brown's Island.

Just below the site of Gilchrist's Old Mill occur some gravel-bars, and a little farther down a series of reefs continues almost without interruption to the head of Gilchrist's Island. The river all along is shallow, and the water we have retained so far must still be kept by means of retaining-dams down to the head of Gilchrist's Island.

The fall from the Old Mill (foot of fall) to the head of Gilchrist's Island is 5.10 feet in 4,700 feet, and in order to secure good water over this distance a lock with 10 feet lift must be established near the head of Gilchrist's Island.

For about 2,000 feet below this point the water is shallow and rapid, with a fall of 3.5 feet down to about station 427, then the channel becomes narrower, averaging from 300 to 400 feet in width, and is from 3 to 8 feet deep.

Opposite station 490 the channel becomes shallow again, and at station 496 a reef extends across with only about 1.6 feet of water on it. The fall here is 3.70 feet in about 1,000 feet.

This shoal corresponds to the "big jump" just below the mouth of Elk River.

To overcome this shoal and the one above, a lock becomes necessary. It was thought the best place for it would be just below this last shoal; but as the water from here to the foot of the island does not reach 4 feet in depth, I think it would be better to have the lock near the foot of the island, below which there is again good deep water across the whole bed of the river.

Nance's Reef, at station 574, is 2,400 feet below the foot of Gilchrist's Island; the best channel through it will be found about 300 yards from the north bank of the river, and is the present low-water boat-chute.

Some excavation will be required here to deepen and broaden the channel. The fall being only about 0.3 feet will be no obstacle to navigation.

The present width of the "chute" through this reef is about 50 feet, with an average depth of 2.5 feet at lowest stage of water.

Above the crest of the reef are many large cube-shaped rocks, measuring from one to four cubic yards, lying close together in the channel, which it will be necessary to remove. Channel to be 100 feet wide.

From this reef to the Big Muscle Shoals, or the mouth of the canal, there are no obstructions, the depth of water being from 4 to 12 feet.

This being the last obstruction, the survey closed here, and the boats were dropped down the river to be left at First Creek, or in the mouth of the canal, in accordance with instructions received from your office dated November 23, 1876. The water was found too low, however, to allow the passage of the boats down to First Creek, and the mouth of the canal was found some 2 feet above the level of the water in the river, with a heavy growth of trees completely shutting off the entrance. We were compelled then to tie up just above the mouth of the canal.

From inquiry at Mr. Gordon's camp, I learned he had no men to spare to take charge of the boats until the stage of the river would permit their passage over the shoals. I therefore left the boats in charge of Messrs. E. A. Crallé and W. S. Scott.

ESTIMATE FOR IMPROVEMENT.

From Head of Brown's Island to Foot of Milton's Bluff.

14,800 linear feet of riprap dams, at $10 per linear foot..................	$148,000 00
5,990 cubic yards rock-excavation, at $3 per linear foot.........	17,970 00
	165,970 00

Canal from foot of Milton's Bluff to Gilchrist's Old Mill-dam.

4,047 cubic yards of rock-excavation, at $1.50	$6,070 50
150 cubic yards old dam to remove, at $1	150 00
6,400 cubic yards earth-excavation, at 0.25	1,600 00
2,500 cubic yards earth-embankment, at 0.25	625 00
1 lock, 12 feet lift	100,000 00
	274,415 50

From Old Mill-dam to foot of Gilchrist's Island.

6,500 linear feet of riprap dams, at $10 per linear foot	65,000 00
13,528 cubic yards of rock excavation, at $3 per linear foot	40,584 00
2 locks, 10 feet lift each, at $100,000	200,000 00
	579,999 50

Nance's Reef.

1,500 cubic yards rock-excavation, at $6	9,000 00
	588,999 50
Adding 25 per cent. for engineering and contingencies	147,250 00
Total	736,249 50

Very respectfully, your obedient servant,

PAUL LE HARDY,
Assistant Engineer.

Captain W. R. KING,
Corps of Engineers, U. S. A.

R 3.

IMPROVEMENT OF CUMBERLAND RIVER.

All the work done during the year on this river has been carried on by hired labor, under the immediate supervision of Capt. L. C. Overman, Corps of Engineers, and has made good progress during the time it has been possible to carry it on.

The exhaustion of one appropriation before the next one was made available has limited the working season to about 6 months below Nashville, and 3½ months on the upper river.

Work upon this river has been divided by the acts of Congress making appropriations into five parts, as follows:

1. Below Nashville, Tennessee.
2. From Nashville to the Kentucky line.
3. From Kentucky line to the foot of Smith's Shoals.
4. Smith's Shoals.
5. From Smith's Shoals to the Falls of the Cumberland.

For a statement of the commercial interests to be benefited by the improvement of the Cumberland River, see report of Captain Overman, appended hereto.

I.—BELOW NASHVILLE.

Work on this section of the river was in progress at the beginning of the year, and was continued, with the exception of parts of the months of August, October, and November, 1876, when it was interrupted by high-water, until January, 1877, when the available funds were nearly exhausted. The boats, tools, and other property were then collected and placed in charge of watchmen at convenient points.

During the unprecedented floods in January, 1877, when such havoc

was created on a number of western rivers, some of the boats were swept from their moorings and carried down toward the mouth of the river, but they were recovered and brought back with but little loss, excepting for salvage and towage.

The work has been distributed among the obstructions as follows:

Harpeth Shoals, 335 cubic yards rock excavated from channel.
Harpeth Shoals, 1,500 cubic yards stone put in dams.
Davis Ripple, 700 cubic yards stone quarried for dams.
Davis Ripple, 1,625 cubic yards stone put in dams.

In addition to this, a large number of snags, loose rocks, and overhanging trees were removed at various points between Nashville and the mouth of the river.

Original estimate of cost of improving the Cumberland River below Nashvile, $248,821

The following appropriations have been made for this part of the river:

Act of March 3, 1871	$30,000 00
Act of June 10, 1872	20,000 00
Act of March 3, 1873	25,000 00
Act of March 3, 1875	25,000 00
Total	100,000 00

There has been expended for its improvement—

In 1872	$15,901 57
In 1873	8,185 67
In 1874	21,506 04
In 1875	29,049 86
In 1876	12,365 25
In 1877	12,654 98
Total	99,663 37

Money statement.

July 1, 1876, amount available	$12,991 61
July 1, 1877, amount expended during fiscal year	12,654 98
July 1, 1877, amount available	336 63
Amount (estimated) required for completion of existing project	148,821 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	100,000 00

II.—ABOVE NASHVILLE.

1. FROM NASHVILLE TO THE KENTUCKY LINE.

An appropriation of $15,000 for this section of the river was made by act of August 14, 1876, but was not made available until February, 1877, when steps were immediately taken to organize working-parties. The boats and tools, no longer needed below Nashville, in consequence of the stoppage of work there, were brought up, repaired, and utilized. Since that time the following work has been done:

At Holliman's Island Shoals.

3,285 cubic yards of stone quarried for dams.
1,300 cubic yards of gravel excavated from channel.

At Sand Shoals.

2,640 cubic yards of stone quarried for dams.
380 cubic yards of rock excavated from channel.

At Cub Creek Shoals.

2,385 cubic yards of stone quarried for dams.
440 cubic yards of rock and gravel excavated from channel.
33 logs and overhanging trees removed from channel.

At Bartlett's Bar.

1,710 cubic yards stone quarried for dams.
3 logs removed from channel.

Money statement.

Amount appropriated by act approved August 14, 1876		$15,000 00
July 1, 1877, amount expended during fiscal year	$7,817 73	
July 1, 1877, outstanding liabilities	3,315 21	
		11,132 94
July 1, 1877, amount available		3,867 06
Amount (estimated) required for completion of existing project		107,155 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		50,000 00

2. FROM KENTUCKY LINE TO THE FOOT OF SMITH'S SHOALS.

An appropriation of $10,000 was made for this section at the same time and under similar circumstances to that just mentioned.

Early in May working parties were organized and the work started at Wild Goose Shoals, with the result given below, viz:

300 cubic yards of rock quarried for dams.
150 cubic yards of rock excavated from channel.
50 cubic yards of gravel excavated from channel.

Money statement.

Amount appropriated by act approved August 14, 1876		$10,000 00
July 1, 1877, amount expended during fiscal year	$1,247 80	
July 1, 1877, outstanding liabilities	844 37	
		2,092 17
July 1, 1877, amount available		7,907 83
Amount (estimated) required for completion of existing project		81,600 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		40,000 00

3. SMITH'S SHOALS.

The first appropriation, $25,000, was also made for this work by act of August 14, 1876, and was made available in February, 1877.

This obstruction, consisting of a succession of bad shoals, named, beginning with the lower one, Mill Shoal, Long Shoal, White Cliff Ripple, and Shadowen Shoal, having a total length of over 8 miles, and a fall of 55 feet, is the most formidable obstruction between the mouth of the Cumberland River and the Great Falls, 374 miles above Nashville.

The improvement of these shoals is very much needed to enable vessels to reach the coal fields in the vicinity of Rock Castle River, as well as to furnish an outlet for the agricultural products of that country.

For a report on the survey of these shoals, see Appendix R 5 to Report of the Chief of Engineers, 1875.

The present scheme of improvement is being carried on in accordance with the recommendations in that report, with a view to securing additional depth of water in the channel, so as to increase the number

of "boating tides" for coal-boats during the season. From the report referred to it will be seen that at present eight opportunities occur for loaded boats to go down from the foot of the shoals to Nashville, while there is but one to pass over the shoals. As the river below the shoals is being improved, there is still greater advantage to be obtained by increasing the depth of water on the shoals.

While the present work is more particularly designed to improve down-stream navigation, I believe it can, at a very small cost, be utilized for up-stream navigation by adopting what is known as the Belgian system of towing, by means of a wire rope. Instead of leaving the rope on the bottom of the channel, however, it would probably be better to coil it on a drum as the boat ascends the rapids.

I believe there are but two places on the shoals where this auxiliary would be necessary to enable ordinary steamboats to ascend—one about 3 miles long, and the other less than 1 mile. At each of these points could be stationed a small, staunch scow, carrying a 15 or 20 horse-power engine and a drum large enough to hold the necessary length of rope, to be wound up by the engine. This whole outfit need not cost more than $10,000 or $15,000 for both places, and the running-expenses would probably be much less than the cost of operating a system of locks.

The cost of a system of locks and dams for these shoals has not been estimated in detail, but it would necessarily be very great, probably more than $1,000,000; and it should be remembered that the passage of locks causes delay to down-stream as well as to up-stream navigation, whereas the open channel and towage system provides not only a free but an *accelerated* passage down stream.

I am not fully prepared at present to recommend a trial of this system at Smith's Shoals, but when sufficient progress has been made in providing a suitable channel and further data have been obtained relative to the velocities and direction of the current at certain points, a more detailed statement of the matter will be presented.

In the mean time it may be stated that the possibility of utilizing the work now going on to provide for an up-stream navigation gives additional importance to the work and furnishes another reason for its completion without delay.

The work done on this section during the fiscal year is as follows, viz:

6, 120 cubic yards of stone quarried for dams.
3, 060 cubic yards of stone put in dams.

Money statement.

Amount appropriated by act approved August 14, 1876		$25, 000 00
July 1, 1877, amount expended during fiscal year	$7, 427 11	
July 1, 1877, outstanding liabilities	4, 884 49	
		12, 311 60
July 1, 1877, amount available		12, 688 40
Amount (estimated) required for completion of existing project		45, 000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		45, 000 00

4. FROM SMITH'S SHOALS TO THE FALLS OF THE CUMBERLAND.

The appropriation for this work, of $2,000, made by act of August 14, 1876, was made available in February, 1877.

As it was deemed advisable to organize parties for the other sections first, nothing was done on this section. It is expected, however, that all the work that the appropriation will admit of will be done before the close of the present working season.

Money statement.

Amount appropriated by act approved August 14, 1876	$2,000 00
July 1, 1877, amount available	2,000 00

The estimates of cost of improving the Cumberland River *above Nashville* are as follows:

From Nashville to the Kentucky line, (Shut-in Shoal)	$122,155 00
From Kentucky line to Smith's Shoals	91,609 00
(See Report Chief of Engineers, 1872, pages 471 and 472.)	
For Smith's Shoals	70,000 00
(See Report Chief of Engineers, 1875, page 796.)	
Total estimate	283,764 00

Appropriated by act of August 14, 1876:

From Nashville to the Kentucky line	$15,000 00
From Kentucky line to the foot of Smith's Shoals	10,000 00
For Smith's Shoals	25,000 00
From Smith's Shoals to the Falls of the Cumberland	2,000 00
Total appropriated	52,000 00
Amount expended	16,492 64

This work is, I believe, in the collection-district of New Orleans. The amount of revenue collected at the nearest port of entry is unknown to me.

REPORT OF CAPTAIN L. COOPER OVERMAN, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
Nashville, Tenn., November 7, 1876.

CAPTAIN: In reply to your letter of November 1, I have to respectfully submit the following:

There are in all about 14 steamers engaged in commerce on the Cumberland: 9 of from 300 to 500 tons each, and 5 of from 125 to 260 tons; the latter are alone able to go in all parts of the river. Average tonnage is therefore about 320 tons. These steamers run between Nashville and the various cities on the Cumberland, Tennessee, Ohio, and Mississippi rivers. During high-water season the smaller class of steamboats also ascend Caney Fork and Obed's River, branches of the Cumberland.

The Cumberland River is navigable for all of the above steamboats for 6 months in the year from Nashville to the mouth of the river; from 6 to 8 months from Nashville to the mouth for boats drawing 3 feet or less, and from 9 to 10 months from Nashville to the mouth for boats of about 20 inches draught. Distance, 192 miles.

Above Nashville the Cumberland is navigable to Point Burnside, (crossing point of the Cincinnati Southern Railroad,) a distance of 358 miles, for from 4 to 6 months, for steamers of 3 feet draught or less, and from 2 to 3 months for the larger boats.

From Nashville to Bucksville, 230 miles above, the Cumberland is navigable for from 5 to 7 months for steamers of 3 feet draught or less, and from 3 to 5 months for larger boats.

From Nashville to Carthage, 120 miles above, the Cumberland is navigable from 6 to 8 months for steamers of 30 inches draught or less, and from 4 to 5 months for the larger boats.

Flat-boating is not carried on extensively upon the Cumberland, except to bring out coal from points above Point Burnside, and this is only practicable during occasional high stages of river, about four or five during the year. A small quantity of produce and some tobacco find their way to a market by aid of the flat-boats.

Table of exports and imports of Nashville by river.

Articles.		Exported by river.	Received from above Nashville.
Cotton	bales	3,785	[illegible]
Tobacco	hogsheads	5,487	[illegible]
Corn	bushels	196,000	[illegible]
Oats	bushels	2,680	[illegible]
Wheat	bushels	1,080	[illegible]
Flour	barrels	10,483	[illegible]
Salt	barrels	7,340	[illegible]

Also about 10,000 tons of miscellaneous freight. Fifteen million feet of saw-logs are annually floated from the upper river to Nashville, and about 7,500,000 feet are floated on the lower river. About 500,000 bushels of coal are annually shipped by the mines above Nashville. There are nine furnaces for the manufacture of pig-iron below Nashville, on the river, whose annual average product equals 19,000 tons of metal.

The exports by river, which now amount annually to about $10,000,000, might be increased to $20,000,000, or more, were the river more reliable for navigation.

Very respectfully, your obedient servant,

L. COOPER OVERMAN,
Captain of Engineers.

Capt. W. R. KING,
Corps of Engineers.

R 4.

IMPROVEMENT OF COOSA RIVER, GEORGIA AND ALABAMA.

As soon as the appropriation of $30,000 for the improvement of the Coosa River, act of 1876, was made available, Lieut. William L. Marshall, Corps of Engineers, was directed to proceed to Rome, Ga., and organize parties for the immediate prosecution of the work. After an examination of the river, from Rome, Ga., to Greensport, Ala., the portion of the river at present navigated, during a very low and hence a very favorable stage, he selected 13 shoals upon which there are less than 2½ feet depth at low-water, and it was decided to begin work on these shoals. Parties were therefore organized, and the necessary boats, tools, &c., procured, and work commenced at Horse-leg Shoals, 1½ miles below Rome.

Other parties will at once be set at work on the shoals below, and it is expected that by the end of the present working season this portion of the river will be put in good navigable condition.

Another important part of the improvement, which will be begun as soon as practicable, is that part of the river between Greensport and the Selma, Rome and Dalton Railroad Bridge. The obstructions here are of a more formidable character and will require considerable money for their removal, but it is believed that the importance of the work will amply justify the expenditure.

The first object gained will be to open the coal-fields of Saint Clair County, Ala., to the people of Rome and the owners of the various iron-works and other manufacturing establishments along the Coosa, which are languishing for the want of cheap coal.

Second, it will furnish an outlet for the agricultural products of a large section of Northeastern Alabama and Northwestern Georgia, and I am informed that it would enhance the value of large tracts of land still owned by the United States; and, finally, it will supply an important link in the navigable water-line of over 800 miles in length, consisting of the Coosawattee, Oostenaula, Coosa, Alabama, and Mobile rivers, extending from near the Tennessee line to Mobile, Ala.

In his report of 1871, (Report of Chief of Engineers 1871, p. 564,) Gen. J. H. Simpson says:

> The testimony of the pilots and steamboat men generally is to the effect that the Coosa River is always navigable from its mouth to Wetumpka whenever the Alabama River is navigable from Mobile to Montgomery. As it is very seldom that navigation is closed between Mobile and Montgomery because of the low stage of water, it is fair to assume *that the opening of the Coosa River to navigation between Wetumpka and Greensport will be the virtual opening of a channel for direct trade between Rome, Ga., and Mobile, Ala., via the Mobile, Alabama, and Coosa rivers, &c.*

Of the 815 miles, including the Oostenaula and Coosawattee rivers, that would thus become navigable all but 137 miles, from Wetumpka to Greensport, are now navigated by steamers.

The Coosa River is an exceptionally favorable one for improvement, since its mean depth is greater in comparison with its averaged width than most of the western rivers, and its banks and channel are generally well defined and permanent. The necessity for its improvement has been repeatedly urged by legislatures, commercial societies, and engineers.

The original estimate for the improvement of the Coosa River from the Selma, Rome and Dalton Railroad Bridge to Greensport was $470,668. (Report of Chief of Engineers, 1872, p. 543.)

This estimate was based on a minimum depth of channel of 4½ feet at low-water. Lieutenant Marshall is of the opinion that a depth of 3 feet, which would probably be sufficient for all present needs of commerce, can be obtained for less than two-thirds of that sum, or $313,000.

It is also probable that a still further reduction can be made by substituting at some of the shoals, as at Ten Islands and Whistenant's Shoals, wire-rope towage, as suggested for Smith's Shoals, on the Cumberland River, for the more expensive system of locks and dams.

The estimates already submitted of the cost of improving the Coosa River are as follows:

From Greensport to Selma, Rome and Dalton Railroad Bridge	$470,668
From Great Wills Creek to Rome, Ga	81,679
Total	552,347

Major McFarland states that the cost of the improvement from Great Wills Creek to Rome will probably amount to $180,000.

This is for a depth at low-water of 4 feet. For a depth of 3 feet at the same stage the cost would be not more than half this amount.

(See Report of Chief of Engineers, 1875, p. 662.)

This work is, I believe, in the collection-district of Mobile. The revenue collected at the nearest port of entry is unknown to me.

Money statement.

Amount appropriated by act approved August 14, 1876		$30,000 00
July 1, 1877, amount expended during fiscal year	$239 41	
July 1, 1877, outstanding liabilities	227 71	
		467 12
July 1, 1877, amount available		29,532 88
Amount (estimated) required for completion of existing project		522,347 00
Amount that can be profitably expended in fiscal year ending June 30, 1879		100,000 00

R 5.

IMPROVEMENT OF HIAWASSEE RIVER.

An appropriation of $10,000 (act of August 14, 1876) was made available for the improvement of this river on the 1st of May, 1877, and steps were immediately taken for the organization of working parties, and the preparation of boats, tools, &c., for carrying on the work by hired labor, it being of such a nature that it could not be specified with sufficient accuracy to secure the Government interests in a contract.

Assistant Engineer John S. Crary was placed in immediate charge of the work, and made a careful examination of the river from Benton Landing to the Tennessee.

The obstructions known as Matthews' Shoals and Magil's Island Shoals were selected as the first to be improved, and work was imme-

diately commenced on them, and was making good progress at the end of the fiscal year.

At Matthews's Shoals a quarry has been stripped of 200 cubic yards of earth, and 400 cubic yards of rock were quarried.

At Magil's Island Shoals 140 cubic yards of earth were stripped from a quarry, and 200 cubic yards of rock quarried. Work in the channel will be commenced as soon as the water gets a little lower, and work at Blackbird Shoals will be started early in July.

A question which is likely to arise as soon as this work is a little further advanced is, whether the East Tennessee Railroad Company shall be compelled to put a draw in their bridge across this stream at Charleston? This bridge is only 36 feet above low-water, and scarcely anything above extreme high-water, so that at low-water the ordinary class of boats upon the Tennessee and its tributaries can only get under the bridge by taking down their chimneys and pilot-houses, while at high-water they are unable to pass at all. Should Congress decide to compel the company to put in a draw, I suppose it will require a special enactment to that effect, either making an appropriation for the purpose, or requiring the company to build it at their own expense. On the other hand, should it be decided not to require a draw, the difficulty will have to be obviated by taking advantage of the low-water season, and building suitable boats for the purpose, or adapting to it some of the smaller ones now in use, by lowering their pilot-houses and hinging their chimneys, as is now done on the Ohio and other western rivers.

In the absence of any authority in the premises, I have not mentioned the subject to the railroad company, but in view of the heavy traffic over this bridge, as compared with that on the river, and of the fact that their bridge has been built and used for many years without protest, they would be decidedly opposed to putting in a draw.

The original estimate for improving the Hiawassee from Savannah Ford to the Tennessee River is	$20,000 00
Amount appropriated, act of 1876	10,000 00
	10,000 00

In the report of the examination of the Hiawassee (Report of Chief of Engineers, 1875, p. 809) it is stated that the examination included a part of the Ocoee, viz, "from Savannah Ford to its junction with the Hiawassee," which is in error, since Savannah Ford and all the obstructions mentioned in the report are on the Hiawassee itself.

The advantages to commerce to be derived from the improvement of the Hiawassee are set forth in the report just referred to, and I am at present unable to make any material addition to those stated therein; but as the amount required to complete the work is comparatively small, I think no further arguments will be needed to secure the necessary appropriation.

Money statement.

Amount appropriated by act approved August 14, 1876		$10,000 00
July 1, 1877, amount expended during fiscal year	$281 20	
July 1, 1877, outstanding liabilities	703 20	
		984 40
July 1, 1877, amount available		9,015 60
Amount (estimated) required for completion of existing project		10,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879.		10,000 00

R 6.

IMPROVEMENT OF OCMULGEE RIVER, GEORGIA.

The river and harbor act of 1876 appropriated $15,000 for the improvement of the Ocmulgee River, in the State of Georgia, and on the 31st of May, 1877, I was notified by the Chief of Engineers that the amount had been made available, and that a project was required for its expenditure.

Having been informed that the railroad bridge at Hawkinsville had effectually barred all navigation above that point, I so reported to the Chief of Engineers, who directed work to be commenced between Hawkinsville and the junction of the Ocmulgee with the Oconee.

Steps were then taken to organize the necessary working-parties for beginning active operations. The work was placed in immediate charge of Assistant Engineer B. W. Frobel, who was, at the close of the fiscal year, engaged in making an examination of the river, and procuring the necessary boats and other tools and supplies for a vigorous prosecution of the work.

It is hoped that the amount of the appropriation will be more than is required for the river below Hawkinsville, and if so, authority will be asked to continue the improvement above Hawkinsville toward Macon.

This work was so recently placed in my charge, that I have been unable to collect any reliable statistics as to the probable benefits to be derived from this improvement; but should it be decided at any time to connect the Ocmulgee with the Tennessee by canal, there can be no doubt that the work now being done will be fully utilized.

This work is in the collection-district of Brunswick, Ga., the nearest port of entry being Brunswick, Ga. I have not ascertained the amount of revenue collected there. The nearest permanent structures belonging to the United States are probably the beacons on Wolf Island, near Darien, Ga.

The original estimate of the cost of the work of improving the Ocmulgee River, providing a channel 80 feet wide and 4 feet deep, as given by Mr. B. W. Frobel, (Report of Chief of Engineers, 1875, Part II, p. 671,) was as follows:

From Macon to Hawkinsville	$42,911 00
From Hawkinsville to the mouth of the Oconee	8,216 00
	51,127 00
To which was added 10 per cent. for contingencies	5,113 00
	56,240 00

Maj. W. McFarland states that the cost of the same improvement (page 670, same report) "will be not less than double that given in the estimate."

Money statement.

Amount appropriated by act approved August 14, 1876	$15,000 00
July 1, 1877, amount expended during fiscal year	46 67
July 1, 1877, amount available	14,953 33
Amount (estimated) required for completion of existing project	41,240 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	41,240 00

R 7.

IMPROVEMENT OF OOSTENAULA AND COOSAWATTEE RIVERS.

No work was done on either of these rivers, the available funds having been nearly exhausted in 1876, since which time no appropriation has been made.

A small balance ($22.06) of the old appropriation has been expended for the care and preservation of boats and other property belonging to the work. The estimates made for the improvement of these rivers are—

For the Oostenaula River	$12,000 00
For the Coosawattee River	16,208 50
	28,208 50

There have been appropriated—

For the Oostenaula River, act of 1874	$10,000 00
For the Oostenaula and Coosawattee Rivers, act of 1875	5,000 00
	15,000 00

The whole of this amount has been expended.

Money statement.

July 1, 1876, amount available	$22 06
July 1, 1877, amount expended during fiscal year	22 06
Amount (estimated) required for completion of existing project	13,208 50
Amount that can be profitably expended in fiscal year ending June 30, 1879.	13,208 50

R 8.

IMPROVEMENT OF ETOWAH RIVER, GEORGIA.

An appropriation of $10,000 for the improvement of the Etowah River, act of August 14, 1876, was made available for that work on the 29th of May, 1877, and I was directed by the Chief of Engineers to prepare a project for the prosecution of the work under that appropriation.

As the improvement of this stream is an exceedingly difficult job, owing to the great number and frequency of shoals and rapids, the estimated cost of improving the first 50 miles above Rome being $274,718, it was found difficult to devise a plan for the economical expenditure of so small a sum as that appropriated. This will be evident from the fact that the only plans for improvement as yet proposed consist in a series of locks and dams, some ten in number, or a canal alongside the river. (See report of Chief of Engineers, 1872, pages 535-548.) The amount of the appropriation would not be sufficient to warrant the beginning of a single lock, either by contract or by hired labor, since most if not the whole of the amount would necessarily be absorbed in preparatory expenses for beginning the work.

In order to ascertain definitely whether any, and if so what, work could be advantageously commenced at the present time, Lieut. William L. Marshall, Corps of Engineers, was directed to make a re examination of the river from Cartersville to Rome, Ga. This examination was not completed during the fiscal year, and it was not, therefore, possible to complete the project in time to appear in this report. The result of the examination, as since developed, has, however, confirmed

the views already expressed as to the necessity for having more money before the heavy work is begun, and it is respectfully recommended that Congress be asked to make appropriations accordingly.

In the mean time an instrumental survey of the river could be made with a view to locating the necessary locks and dams, and for procuring the necessary data for ascertaining and specifying the work required. This has not yet been done, and will be necessary whether the work is carried on by contract or hired labor.

The report of Lieutenant Marshall on his examination of the Etowah, although not completed within the fiscal year, is hereto appended. No estimate of the total cost of improving the Etowah River can be submitted with this report, as the project for its improvement is as yet incomplete. Only one appropriation has been made for this work, viz, by act of 1876, $10,000.

No expenditures were made during the fiscal year.

Money statement.

Amount appropriated by act approved August 14, 1876	$10,000 00
July 1, 1877, amount available	10,000 00

REPORT OF LIEUTENANT W. L. MARSHALL, CORPS OF ENGINEERS.

ROME, GA., *July* 15, 1877.

SIR: In accordance with your letter, dated June 30, 1877, directing an examination of the Etowah River, with a view of ascertaining whether any local advantage would accrue from the expenditure, at any points along that stream, of the $10,000 appropriated for it by Congress in 1876, I have conversed with people living on its banks; with the Hon. W. H. Felton, M. C., of Cartersville, Ga., who takes great interest in the improvement of this river, and have also made an examination in person of the river between Cartersville and Rome, and have the honor to report:

First. That there is no local interest which can be benefited by local improvements.

Second. That there is no demand whatever for navigation from one point to another along the course of the stream itself, and, as far as I can discover, no demand for the improvement of the Etowah, except a contingent one, *i. e.*, in case the obstructions to the navigation of the Coosa below Greensport, Ala., are removed, so as to open the great coal-fields of Alabama to commerce. The mineral and manufacturing interests of the counties of North Georgia bordering the Etowah demand an interest in the benefits of cheap coal. The opening of the Etowah will then be felt as a necessity. The region about Cartersville and the Upper Etowah is very rich in iron, manganese, barytes, and other minerals. There are many furnaces, for the most part out of blast on account of high-priced fuel, and the entire region suffers from the high rates of transportation charged by the railroads for that commodity.

Third. My examination of the Etowah convinces me that it is impracticable to improve the navigation of that stream without the application of locks and dams. The fall of the river between Owl Creek and Rome, as given by Mr. R. C. McCalla, who examined it in 1872, exceeds 5 feet per mile on an average, which fall is not uniformly distributed, but mostly occurs at the reefs and shoals, which are very frequent in some parts of the river, and at others comparatively few.

At the following points the fall equals or exceeds 7 feet per mile:

1. Near Douthard's Ferry, 4 miles below the Western and Atlantic Railroad bridge at Cartersville.

2. One-half mile below Tumlin's Ferry, or about 15 miles below the Railroad bridge near Cartersville, is a shoal one-fourth mile long, over which there is a fall of 2¾ feet, or 11 feet per mile.

3. At Harden's Ferry, 21 miles below Cartersville, is a succession of rock-reefs, extending for one-fifth of a mile, over which is a fall of 2½ feet, or 12½ feet per mile. River 650 feet wide; 8 inches water on reefs.

4. Three hundred yards below this shoal is another rapid fall of 6½ feet in two-fifths of a mile, or 16.2 feet per mile. The river is obstructed with very large bowlders: is wide, with high banks.

5. Eighteen miles above Rome is a shoal where the fall is nearly 4 feet in one-fourth of a mile, or 16 feet per mile.

6. Fifteen miles above Rome, one-half mile long, over which there is a fall of 6 feet in one-half mile; river with high banks. This shoal is near Duncan Murchison's.
7. Eleven miles above Rome is a shoal of 2 feet fall in 1,200 feet.
8. Seven miles above Rome is a shoal over which is a fall of 3½ feet in one-half mile; banks of river high.
9. Within 5 miles of Rome is a stretch of rapid shoal water with several rock-reefs and gravel-bars, which can be improved to advantage only by a lock and dam.

At all of the above points locks and dams will be required, including the two mill-dams at Cartersville.

There will be required 11 locks and dams between Rome and Cartersville, 41 miles distant.

In addition to the above are many reefs, fish-traps, and gravel-bars, upon which I rarely found as much as 1 foot of water. The river is now about its usual low-water stage.

In this connection I respectfully refer to the report of Mr. J. C. Long, assistant engineer, in the Annual Report of the Chief of Engineers for 1872. From his report I should judge that the river was considerably higher when he made his examination than when I came down it, since at most of the reefs, even where he reports from 18 inches to 2 feet of water, I was compelled to get out and lift the small bateau in which I traveled, over the rocks and shoals, for want of sufficient water to float it.

Mr. Long estimates for a channel 80 feet wide, with 3 feet navigation at low-water, but I cannot believe that it is practicable to secure this depth and width of channel at low-water by other means than locks and dams, for the reason that the stream averages only 250 feet in width, and the depth of water on the shoals at low-water rarely exceeds 1 foot, at many of them, where the fall is considerable, it is much less. If, then, a channel 80 feet wide and 3 feet deep is excavated through the reefs, the discharge of the river will not be sufficient at low-water to fill the channel where the fall is considerable and the current rapid. The lowering of the upper pools thereby caused will also considerably increase the amount of excavation. In other respects I agree with Mr. Long's reports and estimates.

The navigation of the Coosa at low-water is 2 feet. At fourteen places between Rome and Gadsden at extreme low-water there is 2 feet or low-water on the shoals, and the present work on that stream is directed to securing 2½ feet navigation at this stage.

On the Oostenaula the navigation is 2 feet at low-water, and the boat running upon it is 20 feet beam and 120 feet long. If similar navigation is secured upon the Etowah, a channel 40 feet wide and 2 feet deep will be sufficient at dead low-water, and there is water sufficient for securing such navigation.

If it is judged advisable to expend the amount of the present appropriation upon the Etowah, I would then respectfully suggest that, awaiting further appropriations from Congress for the locks and dams, the work begin at Rome and be directed to secure 2 feet navigation at low-water, with channel 40 feet wide over the lower obstructions only, and that for the information of Congress Mr. Long be requested to revise his estimates to agree with this modified plan.

The banks of the Etowah are high throughout, and it may be easily slack-watered, at an expense not exceeding $10,000 per mile, if advantage is taken of all stretches of navigable water.

Very respectfully,

W. L. MARSHALL,
First Lieutenant of Engineers.

Capt. W. R. KING,
Corps of Engineers, U. S. A.

APPENDIX S.

ANNUAL REPORT OF MAJOR G. WEITZEL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1877.

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., July 13, 1877.

GENERAL: I have the honor to transmit herewith my annual reports relating to the works of river and harbor improvements under my charge for the fiscal year ending June 30, 1877.

I am, general, very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

S 1.

IMPROVEMENT OF THE FALLS OF THE OHIO RIVER.

The history and condition of this work during the last fiscal year is fully given in the following report of Capt. A. Mackenzie, Corps of Engineers:

UNITED STATES ENGINEER OFFICE,
Louisville, Ky., June 30, 1877.

SIR: I have the honor to submit the following report of operations on the improvement of the Falls of the Ohio and enlargement of the Louisville and Portland Canal, for the fiscal year ending June 30, 1877.

The work projected at the beginning of the year was as follows: To complete the rock-excavation at the head of the canal; to complete the cross-dam at the head of the falls, leaving an opening of 600 feet on the Indiana side, and making a new opening of 400 feet at the head of the middle channel; to close 400 feet of the Indiana opening and the entire middle opening with movable dams, thus leaving openings in the dam of 1,000 feet during high water, and closing these openings to 200 feet during low water; to place a movable dam at the head of the canal, to assist in flushing out the river-deposit; to build new guard-gates for the new locks, and for the head of the canal; to raise the masonry around the gate-recesses of the middle gates of the new locks, thus allowing the canal to be used with a higher stage of water; to improve the Indiana channel on the falls by removing the worst obstructions.

Of this work, the building of a movable dam at the head of the canal has, upon further investigation, been judged to be unnecessary, and the construction of new guard-gates has been carried on as ordinary repairs of Louisville and Portland Canal.

The removal of rock at the head of the canal, and the building of the dam at the head of the falls, are works which can only be carried on economically during low stages of the river. For the rock-excavation, the gauge-reading at the head of the canal should not be greater than 4 feet, and a reading of 3 feet, or less, is still more preferable. Since November, 1875, there have been but 10 days when the gauge-reading was less than 4 feet, and the lowest reading during this time was 3.7 feet.

None of the work has therefore been attempted. It could have been done at a great cost, but the immediate completion of the work is not so imperative as to justify an increase over estimates based on low water.

During the past year the engineer-property pertaining to this work, such as steam-pumps, drills, timber, tools, &c., has been carefully stored at the locks, and signal-lights have been kept up on the coffer-dam at the head of the canal.

All the work so far done on the improvement is in good condition, excepting the dam at the head of Sand Island; but the condition of this dam is, at present, of but little importance, as the river-channel between the island and the Indiana shore is pretty well filled up, and during low water the entire river is thrown south of the island. The head of the island is well protected by riprap, but its south side continues to wash during low water.

The earthen banks of the canal remain in very good condition, and the Bermuda grass, which it was supposed had been killed by cold, now shows some signs of life. The Osage-orange hedge, planted last year, will in a few years replace the wooden fence which now protects the banks.

A low stage of water is predicted for the fall months, and, if this prediction comes true, work on the dam at the head of the falls, and the rock-excavation at the head of the canal, will be pushed forward rapidly.

Very respectfully, your obedient servant,

A. MACKENZIE,
Captain of Engineers.

Maj. G. WEITZEL,
Corps of Engineers, U. S. A.

The estimates for the work which still remains to be done on this improvement, according to the project, were based upon a stage of water as low as that in which the portion so far completed has been done. The river did not get to this stage during the last year for a sufficient length of time to warrant a beginning, and, as it is not of such imperative necessity as to warrant extravagant expenditure, none was attempted.

If there comes a low-water stage during the approaching fall, the operations will consist of completing the rock-excavation inside of the apron-dam at the head of the canal, and removing a few of the most dangerous spots in the Indiana Chute to facilitate the navigation of the falls by that channel. The masonry around the gate-recesses of the middle gates of the new locks will be raised so that the canal can be used with a higher stage of water. This is of considerable practical importance, as with the present walls and gates there comes a period when the canal cannot be used, and the difference of level between the upper and lower pools is still a little too great to permit the falls to be ascended by ordinary craft.

The completion of the cross-dam at the head of the falls will be suspended for the present. We are engaged in studying the details of a plan for freeing the work as much as possible in periods of coal rushes, by providing a chute down the falls for them. This will answer the purpose much better than an additional enlargement of the canal, and will cost much less, and it will prevent accumulation of coal-boats in the canal and the consequent delays to passenger-steamers.

The proposed improvement will necessitate some slight changes in the cross-dam, and hence the construction of the latter will be temporarily suspended.

It has been ascertained by practical experience that a movable dam at the head of the canal will not be of as much service in clearing it of mud deposits by the facility which it would give to flushing as to warrant the expense. Since the two dredges, the mud-scows, and the tow-boat have been all placed in first-class condition we have had no difficulty in keeping the canal and locks well cleaned out.

It is not necessary now to keep the Sand Island dam in repair, and no more money will be expended upon it.

The reason why this work has cost more than the original estimate was given by me in my annual report for the fiscal year ending June

30, 1874. The excess in cost is entirely due to the manner in which the appropriations were made. If these had been made as I recommended, I am certain that I could have built the work in three good seasons, and at a cost less than my estimate.

The original estimate for this work, as stated in my annual report for the fiscal year ending June 30, 1870, was $1,243,500. There has been allotted and appropriated for it as follows:

1868, allotted	$85,000
1869, allotted	178,200
1870, appropriated	450,000
1871, appropriated	250,000
1872, appropriated	300,000
1873, appropriated	100,000
1875, appropriated	100,000
Total	1,463,200

Of this amount $1,380,549.32 has been expended.

No additional appropriation is required for the next fiscal year.

The work is located in the third collection-district of Kentucky. The nearest port of entry is Louisville, Ky. The amount of revenue collected at this port during the fiscal year was $60,571.25.

The commerce and navigation of the Mississippi River and all its branches will be benefited by the completion of this work.

Money statement.

July 1, 1876, amount available	$89,749 30
July 1, 1877, amount expended during fiscal year	7,098 62
July 1, 1877, amount available	82,650 68

S 2.

SUPERINTENDENCE, MANAGEMENT, AND REPAIR OF THE LOUISVILLE AND PORTLAND CANAL.

On the 31st of last December I made my third special report on this work in order to enable the Secretary of War to comply with the provisions of section 3 of the act of Congress, approved May 11, 1874, entitled:

An act providing for the payment of the bonds of the Louisville and Portland Canal Company.

In addition this is the third annual report on this subject. Of necessity there has been a great deal of repetition.

The annexed annual report of Capt. A. Mackenzie, Corps of Engineers, gives the history and condition of the work during the last year.

We have continued the superintendence and management of the canal according to the same system which has heretofore been pursued. We are continuing the repairs necessary for placing the work in good condition with as much rapidity as the funds on hands will permit.

But a very important subject which has been referred to in all my reports has not received that attention from Congress which its importance demands. I refer to the adoption of a system of rules and regulations for the government of the canal and those using it. (See foot of page 765, Report of the Chief of Engineers for 1876, Part I.) The power to enact such rules should be granted by law to the Secretary of War. My assistants on the canal are absolutely powerless to control matters when there is a rush of business, as always comes with a coal-boat rise.

As Congress has not acted in this matter, I directed Captain Mackenzie to bring the matter to me officially in the shape of a letter.

Accordingly he addressed a communication to me, of which the following is a copy:

OFFICE LOUISVILLE AND PORTLAND CANAL,
Louisville, Ky., March 9, 1877.

SIR: I would respectfully ask to be informed whether, under existing laws, the superintendent of the Louisville and Portland Canal has authority to regulate the movement of boats in the canal, and prevent unnecessary delays? It has been assumed in all yearly reports, and in my letter of March 9, 1876, that until some legislation was had, the superintendent had no means of enforcing his orders. All steamboatmen seem to consider it the duty of the superintendent to provide against their delays from any cause whatsoever. I have always held that when they were detained in the canal by the carelessness or willfulness of others, they should seek redress in the courts. There must be laws especially directed to preventing the obstruction of navigable channels, and the question is whether those injured by the delay or the canal management should prosecute the offender. The superintendent of the canal is most certainly willing to take action and responsibility in the matter if he is justified by law in so doing. The only reference to the subject that I can find is in section 10 of the original charter granted to the canal company by the legislature of Kentucky in 1825. This section states "that if any person or persons shall willfully and knowingly do any act or thing whatever, whereby the said *navigation* or any lock, gate, dam, engine, machine, or other thing thereto belonging, *shall be* injured, or damaged, or *impeded*, or shall commit any willful trespass, or take, or carry away, or conceal, any material, instrument, tool, or other thing belonging to or used in or about the said works, or shall open, or cause the locks to be opened, or attempt to do so, or to pass or repass without the knowledge of the agent or manager to said canal, he, she, or they so offending shall forfeit and pay to the said canal company, their tenant or agent, three times the amount of the cost or damage sustained by means of or through such willful acts, together with costs of suit, to be recovered before any court of competent jurisdiction, and in case of clandestinely taking and carrying away, be liable to a prosecution for theft, as in other cases."

This section was evidently intended to cover the canal company against any loss sustained by them, either in form of property or damages for delays. I do not see that the superintendent can, on the strength of this section, take any action further than to instruct those in charge of boats how and when to move, leaving it for those who sustain any loss by a refusal to obey the orders, to obtain their redress in a court of justice.

I have always given this advice, and have promised to give assistance and furnish such evidence of the delay as might be within the knowledge of the canal management.

I would respectfully ask for a definite decision in this matter, which will either give the superintendent of the canal authority to enforce his orders, or relieve him from the blame and censure of parties interested in the navigation of the canal.

I inclose a note received this morning from the captain of one of the Henderson packets, showing an example of the delays referred to. This same boat, the Whale, caused much trouble last night, delaying several boats. Last month the Robt. Mitchell, drawing much more water than was shown by the gauges, came into the canal, got aground and blocked up the canal for 48 hours, delaying several steamboats. These are but a few examples of many similar delays, willful as far as the offending boats are concerned, but unavoidable as far as the management of the canal is concerned.

Very respectfully, your obedient servant,

A. MACKENZIE,
Captain of Engineers.

Maj. G. WEITZEL,
Corps of Engineers.

I forwarded this letter with an indorsement, of which the following is a copy:

UNITED STATES ENGINEER OFFICE,
Detroit, Mich., March 15, 1877.

Respectfully forwarded. This communication explains itself. I respectfully request a decision on the question presented by Captain Mackenzie. In every one of my reports I have asked that a system of rules and regulations for the government of those using the canal be enacted into law, but so far no action has been taken by Congress. The delays referred to by Captain Mackenzie are liable to bring the canal management into serious discredit.

G. WEITZEL,
Major of Engineers.

To this I have not yet received a reply.

I have had charge of the canal since it was turned over to me by the former management on June 11, 1874. The following table gives, in a condensed form, the financial statement for this period:

	Receipts.	Expenses—		
		For management.	For repairs.	Total.
During June, 1874	$2, 744 85	$2, 490 78	....	$2, 490 78
During fiscal year ending June 30, 1875	54, 814 11	43, 195 66	$2, 691 49	45, 887 15
During fiscal year ending June 30, 1876	78, 102 64	44, 373 56	14, 892 92	59, 266 48
During fiscal year ending June 30, 1877	82, 953 90	46, 323 58	19, 814 89	66, 138 47
Total	218, 615 50	136, 383 58	37, 399 30	173, 782 88

Excess of receipts over expenses, $44,832.62.

Now these permanent improvements and repairs, which have cost only $37,399.30, were estimated to cost at least $54,035. They were made with such economy, because the work was done immediately under the eye of my assistants by days' labor, and the machinery and workshops of the canal were employed, as well as the mechanics and laborers engaged in the management when they were not busy at their legitimate duties.

The $16,635.70 which was saved by this method should, therefore, be credited to the canal management.

It will cost about $6,000 more to make the improvements, for which I have no authority. I propose to ask for authority, then, to repair the old locks, converting the three chambers into two, so that they will have the capacity to pass nearly all the vessels that now use the canal. Then I will ask for authority to give the lift-gates and miter-walls of the new locks a complete overhauling and improvement, so that much of the labor and time now consumed in operating these locks may be permanently saved. After this is done I propose to ask for authority to erect the requisite number of plain cottages near the locks for the accommodation of the employés, so that they can be called out rapidly at night, when needed. And then I will ask for authority to gradually enlarge the existing dry-dock, so that it will accommodate the vessels that use the new locks. At present it has only the dimensions requisite for docking the vessels that could use the old locks.

When this work is done everything will be in splendid working condition, and then it will be safe still further to reduce the rates of toll, which are now only about one-tenth of those which were charged by the former management.

It will be seen from my various reports that the business of the canal is steadily on the increase, and if this increase continues there will be a just demand in a short time for further accommodations. I have suggested a method for meeting this want, in my report on the improvement of the Falls of the Ohio River, which will undoubtedly be printed with this.

Captain Mackenzie, and the employés under him, have continued to administer the affairs of this work with the same economy, fidelity, and industry which have characterized the management since the Government took charge of it.

Annexed hereto is the financial statement for the fiscal year ending June 30, 1877:

Financial statement for fiscal year ending June 30, 1877.

Deposits.		Expenditures.	
Months.	Amount.	Months.	Amount.
1876.		1876.	
July	$6,465 08	July	$3,307 50
August	5,967 33	August	6,989 34
September	5,037 40	September	8,126 33
October	6,727 89	October	3,648 72
November	8,030 01	November	4,227 43
December	4,144 10	December	10,434 06
1877.		1877.	
January	899 56	January	3,431 11
February	9,969 36	February	4,058 95
March	3,867 36	March	5,692 36
April	11,256 46	April	5,244 07
May	11,678 01	May	4,675 87
June	10,390 34	June	6,302 73
	82,953 90		66,138 47

Cash on hand June 30, 1877, $44,832.62.

REPORT OF CAPTAIN A MACKENZIE, CORPS OF ENGINEERS.

LOUISVILLE, KY., *June* 30, 1877.

SIR: I have the honor to submit the following report upon the superintendence, management, and repair of the Louisville and Portland Canal for the fiscal year ending June 30, 1877.

The canal has now been under the management of the United States for three years, but it has only been eighteen months since the surplus of receipts over ordinary expenses justified commencing repairs and improvements. Since the beginning of the year 1876 such work has been carried on, gradually placing the canal and its accessories in perfect working order.

The following is a summary of the work accomplished during the past year:

The repairs of the tow-boat have been completed, and a large fire and wrecking pump has been added to the boat's outfit.

A new hull and a new boiler have been built for dredge No. 2, its engine has been thoroughly repaired, and machinery for raising spuds by steam has been put in.

Dump-scow No. 4 has been rebuilt.

The shops have been extended, and the following additional machines have been set up: one dimension-planer, one boring-machine, one circular saw, and one grindstone. The work done in these shops during the year has caused a saving of $1,841.70, while the total cost of machinery has been but $1,737.20.

A set of new guard-gates, each leaf of which is 47′ 8″ by 46′ 11″ and weighs 66½ tons, has been built and put in at the head of the new locks, and a set of new gates for the head of canal is now almost completed.

The building of these gates at the locks, under the direction of the superintendent of the canal, has resulted in having the work admirably done and in saving many thousands of dollars. The high guard-gates have cost $6,227.59, and the set for the head of the canal will have cost when completed about $4,000. The original estimate for this work, based upon the cost of the lift-gates, which were built by contract, was $24,000.

New winding-machinery has been provided for the middle gates of the new locks, and inch chrome-steel chains have been substituted for the iron chains formerly used. It is expected that this new machinery will greatly facilitate the moving of the gates, and its strength is so great that the annoyance of breakages will be done away with. The new machinery will be applied to all the gates, and when the work is completed, it will cause a yearly saving in operation expenses of about $2,400. The friction-drums at the bottom of the well-holes have been set up anew and greatly strengthened.

The bridge crossing the canal at Eighteenth street has been thoroughly repaired; a new floor has been laid, and the turning-machinery has been improved and strengthened.

Fourteen lamps, furnished by the Light-House Department, have been set up on the lock-walls. The gates and lock-chambers can now be made almost as light by night as by day.

A foundation for the superintendent's office has been completed and work on the building has been commenced.

A second fire-cistern is being built, and hand fire-pumps have been connected with he cistern built last year.

The slopes in the vicinity of the locks have been partially graded and sodded, and the slopes along the canal-banks have been repaired.

The toll-collector's house and the workshops have been painted.

In addition to the work above enumerated, numerous and constant repairs have been made on boats, gates, machinery, &c.

The dredges have removed during the year 95,282 cubic yards of sediment. In October one dredge, notwithstanding numerous delays caused by passing boats, removed 8,322 cubic yards in 26 working days. The tow-boat, while moving dump-scows, has run 2,220 miles.

Three thousand four hundred and thirty-nine boats, with a total undertonnage of 909,933.8 tons, have been passed through the locks. This work has required 899 lockages by day and 704 lockages by night. The gates have been opened and closed 9,618 times, and the lock-hands, in turning the capstans, have each traveled about 2,197 miles.

During the past year the locks have been closed 30 days by ice and 29 days by high-water.

Though the deposits of sediment have been very heavy at times, the dredges have succeeded in removing it as fast as the water fell, and there have been no delays from this cause. The flood of January left a deposit of 10 feet in the lower-lock chamber, and a deposit of 4 inches on top of the upper gates, over which the water stood but 9 days.

The business of the Louisville and Portland Canal is constantly increasing, and it is evident that before many years the present locks will not accommodate all the commerce of the river. Even now, when tows of coal are passing down or fleets of empty barges are passing up, delays are unavoidable, and these delays will, I am confident, become more serious each year.

To provide for this increased commerce, as well as afford an opportunity for occasionally closing and repairing one set of locks without interfering with navigation, a second set should be built. But this building, or at least the completing of a new set of locks, for which money must be appropriated, important as it may be, is a work of the future, and it would be well if some temporary provision could be made for providing means of passing boats when a necessity for closing the new locks may arise. I am of the opinion that the old locks can be made to furnish this relief by converting the three locks into two, each 50 feet wide and about 300 feet long. With such arrangement all boats running during low-water could be accommodated, and the new locks could be closed for several months during the year without interfering with continuous navigation. If this work is only intended as a temporary expedient, to last, say, 5 or 6 years, the expense will not be so great, but that it may be paid from tolls collected.

I append tables giving the detailed receipts and disbursements during the past year. Notwithstanding the large amounts expended for repairs and improvements, the receipts have exceeded expenses $16,871.74.

In conclusion, I would respectfully renew the recommendation made in my report of January 1, which I would ask to be considered as a part of this report.

I am, very respectfully, your obedient servant,

A. MACKENZIE,
Captain of Engineers.

Maj. G. WEITZEL,
Corps of Engineers.

Detailed statement of boats passed through the Louisville and Portland Canal for the fiscal year ending June 30, 1877.

Date.	Steamboats.		Tow-boats.		Model barges.		Square barges.		No. of small boats.
	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	
1876.									
July	88	28, 650	24	4, 492	73	17, 837	79	18, 286	5
August	91	29, 691	19	3, 321	37	9, 530	65	13, 354	6
September	72	20, 489	19	3, 064	31	7, 092	80	20, 502	10
October	99	34, 813	26	3, 152	61	14, 179	88	18, 539	19
November	103	40, 633	25	4, 155	77	19, 808	152	32, 346	36
December	29	13, 476	6	1, 001	10	2, 656	46	10, 093	8
1877.									
January	3	858	6	1, 361	5	1, 075	30	9, 323	5
February	61	27, 186	38	5, 518	49	11, 315	201	59, 630	13
March	40	17, 286	11	1, 491	26	6, 480	53	12, 333	12
April	56	25, 884. 8	38	6, 192	60	15, 101	355	103, 031	16
May	74	32, 682	39	6, 837	77	19, 969	236	60, 471	23
June	79	34, 347	44	5, 720	82	19, 931	212	54, 753	11
Total	795	305, 995. 8	295	46, 304	588	144, 973	1, 597	412, 661	164

Statement of receipts of Louisville and Portland Canal for the fiscal year ending June 30, 1877.

No.	Designation.	No. of tons.	Price per ton.	Amount collected.
795	Steamboats	305, 995. 8	$0 10	$30, 599 58
295	Tow-boats	46, 304	10	4, 630 40
588	Model barges	144, 973	10	14, 497 30
1, 408	Square barges	364, 467	08	29, 157 36
189	Square barges	48, 194	05	2, 409 70
164	Small boats	....	*5 00	820 00
	Receipts from tolls			$82, 114 34
	Receipts from dry-dock			275 96
	Receipts from towing			116 50
	Receipts from rents			380 75
	Receipts from dredging			62 50
	Total receipts for fiscal year ending June 30, 1877			82, 950 05

* $5 each.

Detailed statement of expenditures of the Louisville and Portland Canal for the fiscal year ending June 30, 1877.

Date.	Lockage department. Labor.	Lockage department. Purchases and repairs.	Lockage department. Total.	Dredge department. Labor.	Dredge department. Purchases and repairs.	Dredge department. Total.	Improvement.	Grand total.
1876.								
July	$2, 195 00	$131 25	$2, 326 25	$940 00	$179 00	$1, 119 00	$3, 525 09	$6, 970 34
August	2, 145 00	159 86	2, 304 86	940 00	412 10	1, 352 10	3, 624 35	7, 281 31
September	2, 209 66	189 75	2, 399 41	943 75	313 29	1, 257 04	515 07	4, 171 52
October	2, 205 00	124 17	2, 329 17	970 66	342 73	1, 313 39	826 96	4, 469 52
November	2, 205 00	129 19	2, 334 19	951 37	246 82	1, 198 19	5, 174 45	8, 706 83
December	2, 205 00	140 69	2, 345 69	940 00	169 10	1, 109 10	1, 679 09	5, 133 88
1877.								
January	2, 330 00	82 49	2, 412 49	905 00	74 18	979 18	394 03	3, 785 70
February	2, 446 67	263 60	2, 710 27	1, 044 56	328 75	1, 373 31	177 96	4, 261 54
March	2, 380 00	645 78	3, 025 78	915 00	366 91	1, 281 91	719 36	5, 027 65
April	2, 358 50	1, 572 78	3, 931 28	928 50	240 62	1, 169 12	878 91	5, 979 31
May	2, 418 33	191 63	2, 609 96	915 00	296 98	1, 211 98	982 87	4, 804 81
June	2, 424 33	862 80	3, 287 13	927 33	260 15	1, 187 48	1, 011 89	5, 546 66
Total	27, 522 49	4, 493 99	32, 016 48	11, 321 17	3, 230 63	14, 551 80	19, 510 03	66, 138 47

REPORT OF DECEMBER 30, 1876.

UNITED STATES ENGINEER OFFICE,
Louisville, Ky., December 30, 1876.

GENERAL: In accordance with your instructions, and to enable the honorable Secretary of War to comply with the provisions of section 3 of the act of Congress approved May 11, 1874, entitled "An act providing for the payment of the bonds of the Louisville and Portland Canal Company," I have the honor to submit the following report on the superintendence, management, and repair of the Louisville and Portland Canal for the calendar year ending December 31, 1876:

My assistant in immediate charge of the work, Capt. A. Mackenzie, Corps of Engineers, has again submitted a complete and full report to me. By my special directions, detailed statistics bearing on all the practical points which will be of interest to the profession were care-

fully gathered, and are submitted in the five tables which are annexed to Captain Mackenzie's report. The latter is annexed hereto, and forms a part of this. It will be seen from it that the past year has been more favorable for navigation than the previous year, and there has been a corresponding gain in the earnings of the canal. The receipts during this period have been $80,766.28; the expenditures, $69,476.21. The surplus on December 31, 1875, was $15,665.53. The surplus on December 31, 1876, was $26,955.60. This surplus was gained in spite of the following work, which was done during the year:

One tow-boat completely repaired.
Two dredges completely rebuilt.
Three dump-scows rebuilt and enlarged.
A machine-shop built.
Eighteenth-street swing-bridge over the canal completely repaired.
A telegraph-line from head of canal to locks, 2 miles long, constructed.
A fire-cistern, with a capacity of 500 barrels, was built.
An osage-orange hedge was planted along the canal, from the new locks to the railroad-bridge, near the head of the canal.
The grounds around the dry-dock were graded, and permanent ways were laid.
A new foundation for the lock-engine was built.

In doing all of this work, we have pursued the policy which we mapped out in the beginning. This was to carry on the repairs in the order of their necessity, and as soon as a proper amount of receipts in excess of expenditures had accrued. This was the only policy we could pursue in the absence of the loan or appropriation of $50,000, which I recommended to be made by Congress in all of my previous reports. In consequence of the good stage of navigation of the river during the past two years and the careful and economical management on the part of my assistants, we have succeeded much better than we anticipated. I am not disposed in this report to renew my recommendation for the above loan or appropriation, but at the same time I cannot make any change in my recommendations previously made for the rates of tolls, &c.

So many things remain still to be done, as Captain Mackenzie's report shows in detail, that it would be extremely hazardous to reduce the present rate of toll. For the reasons also fully given in Captain Mackenzie's report, I recommend that we may, in the contingencies enumerated by him, hire our dredges and steam-pump on the tow-boat Walker Morris.

To recapitulate, I respectfully recommend the following rates of toll, &c., for the calendar year ending December 31, 1877, as being reasonable and fair, viz:

On steamboats and model barges, 10 cents per ton under tonnage.
On square barges, flats, and coal-boats, 8 cents per ton measured capacity.
On steamboats under 50 tons, and flats under 63 tons, $5 per lockage.
On square barges and coal-boats, which have passed through the canal loaded and returning empty, 5 cents per ton measured capacity.
On rafts of logs, &c., measurement and rates same as for flats.
On boats belonging to the United States, no toll.
For the use of dry-dock, $20 for the first day, and $10 additional for each succeeding day.
For towing, the ordinary rates of harbor-boats.
For the use of dredges, $30 for twelve hours' use each.
For the use of the steam-pump on the tow-boat Walker Morris, $2.50 per hour.

I have received authority to construct two new sets of gates, and they have been begun, and will be completed as rapidly as possible.

Since the dredges have been rebuilt, the experience seems to show that it will not be necessary to employ auxiliary means for clearing out the sediment deposited in the canal by flushing it by means of a movable dam at its head, and I do not intend now to build it unless further experience would plainly show it to be of benefit corresponding to its cost.

I beg leave again to call attention to the great importance of enacting into a law "The rules and regulations for the government of the Louisville and Portland Canal and those using it," which were submitted by Captain Mackenzie, and are given in my report dated January 1, 1876, (Ex. Doc. No. 67, H. R., 44th Congress, 1st session.)

In conclusion, I think it only an act of justice to replace on record that the management of this work has been conducted in the most satisfactory and economical manner by Captain Mackenzie and those on duty with him.

Annexed hereto is the financial statement for the calendar year ending December 31, 1876.

I am, general, very respectfully, your obedient servant,

G. WEITZEL,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A.

Financial statement for calendar year ending December 31, 1876.

Deposits.		Expenditures.	
Months.	Amount.	Months.	Amount.
1876.		1876.	
January	$2,953 47	January	$3,551 53
February	1,302 51	February	8,085 98
March	7,654 02	March	3,894 63
April	9,630 92	April	425 10
May	15,305 01	May	7,704 78
June	8,248 54	June	9,030 94
July	6,465 08	July	3,387 58
August	5,267 33	August	6,949 34
September	5,037 40	September	8,136 33
October	6,727 89	October	3,648 72
November	8,030 01	November	4,227 42
December	4,144 10	December	10,434 09
	80,766 28		69,476 31

Cash on hand December 31, 1876, $26,955.60.

REPORT OF CAPTAIN A. MACKENZIE, CORPS OF ENGINEERS.

LOUISVILLE, KY., *December* 31, 1876.

SIR: In accordance with your instructions, I have the honor to submit the following report upon the superintendence, management, and repairs of the Louisville and Portland Canal for calendar year ending December 31, 1876:

PRESENT CONDITION OF THE CANAL.

The canal and the new locks are in good condition, with the exception of the guard-gates. New gates are now being built.

The old locks are very much dilapidated, requiring new lift-gates and new miter-sills. Some necessary repairs on the lower miter-sill have been authorized, but high water has prevented any work on it during the past year. The guard-gates of these locks must be rebuilt very soon.

The dry-dock is in good condition, but is not very serviceable on account of its small size and low gates.

The canal buildings and shops are in good condition; but the latter, being all of wood, can only be considered as temporary structures.

The tow-boat, dredges, and all accessories of the dredging department, have been thoroughly repaired, and are now in perfect order.

WORK ACCOMPLISHED DURING THE YEAR.

Dredging department.—When the United States took charge of the canal in June, 1874' the boats, dredges, &c., were in a very poor condition, and though the necessity of thoroughly repairing this apparatus was then recognized, it was not until the close of the year 1875 that the excess of the receipts over ordinary expenses justified any large expenditure.

A new hull for the tow-boat, built by James Howard & Co., at Jeffersonville, Ind., was launched February 19; but high water and heavy deposits of sediment kept the dredges and old steamboat at work until June 3, when the old boat was dismantled, and the machinery, after thorough repairing, was transferred to the new hull. All re, pairs were comleted and the new boat commenced work July 14. The boat is now in-, perfect order, and is provided with a powerful force-pump, which can be used for wrecking purposes or as a fire-extinguisher.

On the 4th of June, dredge No. 1 was taken into the dry-dock, thoroughly repaired and machinery added for raising the spuds by steam-power. This dredge was again set to work August 4.

The repairs of dredge No. 2, which were commenced September 29 and completed this month, have consisted in building a new hull, a new boiler, and putting in spud-hoisting machinery.

During the year, three dump-scows have been enlarged and thoroughly repaired. They now hold 38 cubic yards each, and, though much larger, are much easier managed than the old scows.

Excepting the building of the hull of the tow-boat, the boiler, and the spud-hoisting machinery of the dredges, all the above repairs have been made at the locks by our own mechanics, assisted by the lock-hands and hired labor, and under the immediate supervision of the superintendent of the canal.

Machine-shop.—The constant repairs required on the boats, gates, bridges, &c., suggested last year the importance of establishing a shop of our own, where the work could be done promptly and cheaply. During the past year, a building has been erected, and the following machines have been put in operation: Two circular saws, one screw and bolt cutter, one drill-press, one grindstone, and one 50 feet dimension-planer. All these machines are run by a small engine, formerly used at the old locks, and nearly all the labor of setting up machinery has been done by the canal mechanics, assisted by the lock-hands. The bolt-machine has cut the nuts and bolts for the dredges, dump-scows, and gates; and, while it costs but $248.20, it has, up to the present time, effected a saving of $254.55.

The saws and planer have prepared all the timber used in rebuilding the dredges and scows, and have now commenced work on the timber for the new gates. The estimated cost of labor already saved by these machines is $439.25; and it will be but a short time before they will, like the bolt-cutter, have saved a sufficient amount to cover their original cost.

Eighteenth-street bridge.—During the latter part of this year, an old contract was found among the records of the city council requiring the canal company to keep the road-bridge crossing the canal at Eighteenth street in repair. In accordance with this agreement, the bridge has been thoroughly repaired.

Miscellaneous work.—A telegraph-line connecting a small office at the head of the canal with the locks has been put in operation.

A fire-cistern, holding 500 barrels, has been built near the shops, and a city fire-alarm box has been placed at the locks.

An osage-orange hedge has been planted the entire length of the canal. It will, in a few years, replace the wooden fence which now protects the slopes.

The ground in the vicinity of the dry-dock has been graded, and permanent ways put up for building, repairing, and launching boats and gates.

Maps and titles of the canal property have been obtained, but the contemplated survey has not yet been made on account of high-water.

A foundation has been built and preparations made for raising the small engine at the new locks above the reach of ordinary floods.

The mechanics have been employed on the extensive repairs of boats, dredges, and scows, and, in addition, have made all ordinary repairs of gates, bridges, machinery, &c.

The principal work done by the lock-hands is shown in the annexed table, which gives number of boats passed through the locks. When not working at the gates, the employés have assisted the mechanics, graded the grounds, planted the hedge, put up telegraph, &c.

The tow-boat, when not employed with the dredges, has furnished assistance to boats and tows.

Office-work.—The office-work has been preparing regular reports of operations and receipts from tolls, compiling statistical information, making plans and specifications for boats, dredges, shops, machinery, &c., and collecting tolls. Attention has been given to plans for permanently improving the canal and reducing expenses. The col-

lection of river and canal water has been continued through the year, the amounts of sediment have been determined, and analyses of the water have been made. One pound of water was taken from the river daily during a low stage, from September 7 to November 8, 1875. The 62 pounds yielded but 65 grains of sediment, while 62 pounds taken in a similar manner from January 10 to March 13, during high-water, yielded 493 grains. Three hundred and seventy-two pounds, taken one pound daily, from July 7, 1875, to July 17, 1876, yielded 2,352 grains of sediment. These specimens were all taken just below the surface of the river, in a strong current. From January 1 to April 1, 1876, specimens of river water were taken from the surface, at mid-depth, and from the bottom. The average yield of sediment to one pound of water was as follows: at surface, 8.82 grains; at mid-depth, 10.43 grains; and at bottom, 11.67 grains.

Numerous analyses of the canal water show that, while the matter thrown into the canal by the city sewers has no injurious effect on the walls or the gates, it does affect the boilers of the steamboats and the dredges. When using the canal water, the large amount of lime and soda washed in from the paper-mills coats the boilers rapidly, and cleaning out is necessary every two or three weeks, while, when using river water, cleaning out once a month is sufficient. The large amount of organic matter washed into the canal from the sewers undoubtedly affects the health of the lock-hands, and is partially the cause of the malarial diseases which are prevalent among them. One thousand grammes of water taken from the canal twelve hours after a heavy rain yielded 0.345 gramme of organic matter.

NUMBER OF EMPLOYÉS AND COST OF LABOR.

The force employed in the management of the canal at the beginning of the year was as follows: One superintendent, one assistant superintendent, one toll-collector and clerk, two lock-masters, four mechanics, one captain and pilot, one foreman, three engineers, and forty-one laborers, watchman, firemen, &c. The regular pay-roll then amounted to $3,330 per month, but during the year it has, by the discharge of three men, been reduced to $3,105 per month. The number of employés is now as low as it can be made until machinery replaces man-power in the lock-gates. During the year extra labor at the locks has cost $229.85, and the night-work of the dredge-force has cost $265.42.

RATES OF TOLL, ETC.

No change has been made in the rates of toll since they were fixed by the Secretary of War, January 25, 1875. A recommendation made last year to reduce the rate on empty barges on return-trips was not acted on. This reduction would have decreased the receipts $5,078.88 during the past year,

Considering the increase in the river commerce, the present rate of toll, including the recommended reduction, will, I think, be amply sufficient for paying all expenses of management and repair, and, in addition, will permit the necessary permanent improvements to be gradually made. If all parts of the canal were in perfect condition, a reduction in the rate of toll could now be made; but it is hoped, by the accumulation of a surplus and by the judicious expenditure of a portion of the income for radical improvements, to greatly reduce the operating expenses, and thus permit in the future a much greater reduction than could now be made.

Many companies and private individuals are of the opinion that there should be some reduction made in their favor on account of their extensive use of the canal; for instance, the Henderson Packet Company, when the falls are not navigable, have two boats through daily, and have paid as tolls during the past year $10,483.10. It has also been suggested that a reduction should be made on barges of certain sizes, as an inducement to owners to build boats which, when combined, would exactly fill the lock-chambers. While these suggestions are worthy of consideration, I should hesitate to recommend any change in the present system of tolls; it is simple and gives rise to no questions of judgment or disagreements between parties using the canal and those managing it.

RECEIPTS AND DISBURSEMENTS.

During the year 1876 the river has been at a most favorable stage for navigation, and our own records, as well as the report of the Cincinnati Chamber of Commerce, show that the river commerce has been constantly increasing. A portion of this increase is undoubtedly due to the enlargement of the canal and the reduction of tolls.

During the year there have been but 4 days when there was less than 4 feet in the canal, and only 35 days when the gauges showed more than 11.5 feet.

The receipts for the year have amounted to $80,762.27, being $10,586.66 in excess of the receipts of 1875.

The expenses of the past year have been $69,476.21. Of this amount, $25,410.52 was

expended for permanent improvements, leaving, as the cost of superintendence, management, and repairs, $44,065.69. Notwithstanding the extensive expenditures for permanent improvements, the receipts have exceeded the disbursements $11,286.06.

All the surplus receipts could have been expended during the year had work already authorized been hurried; but as the work is, to a great extent, done by our regularly-employed mechanics and laborers, it was more economical to do it slowly, and not increase the labor-account by the employment of a large number of men.

As in previous years, a large proportion of the receipts have been from iron-ore, coal, and salt. Boats so loaded have contributed the following amounts:

684 boats, carrying about 9,743,000 bushels coal	$16,600 68
136 boats, carrying about 246,900 barrels salt	2,572 86
284 boats, carrying about 85,108 tons iron-ore	16,691 71
Empty boats returning	13,543 68
Total	39,408 93

A few companies and individuals have contributed largely. The following figures, though not absolutely correct, are a close approximation:

Henderson Packet Company	$10,483 10
W. H. Brown	8,595 06
Kanawha Salt Company	6,165 69
John A. Wood	4,276 20
S. Horner & Co	2,260 94
Total	31,780 99

WORK PROJECTED FOR NEXT YEAR.

Experience is constantly developing new work, and it is impossible to make certain predictions at the beginning of the year; but it is probable that, if money and time are available, the following work will be attempted during the coming year:

Superintendence, management, and repairs	$45,000 00
Night-work and extra labor	600 00
Total	45,600 00

Two sets of lift-gates for old locks	$6,000 00
One set guard-gates for old locks	6,000 00
Office for superintendent	1,000 00
Additional cisterns and fire-apparatus	1,000 00
Surveying land and making corners	1,000 00
Repairing miter-sills of old lock	600 00
Coal-elevator	2,000 00
Lathe and additional machinery	1,000 00
Cottages for lock-hands	6,000 00
New guard-gates at new locks New guard-gates at head of canal	22,601 17
New masts for suspending gates	

WORK FOR THE FUTURE.

The old locks should be rebuilt, converting the three chambers into two, and the bridge crossing these locks should be moved. It is a question for consideration whether, when the old locks are repaired, they should not be made wider; with their present width they would accommodate but a small portion of the boats on the Ohio and Mississippi Rivers.

The dry-docks should be enlarged and the gates should be made higher.

More spacious basins should be provided at the head and at the foot of the locks.

The wall on the north side of the canal should be rebuilt.

The coping of the side-walls and the miter-sills of the new locks should be replaced by harder stone. The banks in the vicinity of the new locks should be graded and protected.

The present wooden shops should be replaced by more permanent structures.

In five or six years it is probable the lift-gates of the new locks will commence to decay and require renewing.

If the river commerce continues to increase, the capacity of the canal will have to be increased, or frequent delays will be unavoidable.

Steam or water power must be applied to the gates, and some means must be devised for facilitating their movement.

The time required for filling and emptying the lock-chambers must, if possible, be reduced.

Of all this work the last two items are in my opinion the most important at present, as they would greatly reduce the cost of management and time of lockage.

The reduced expenses and increased surplus would pay for most of the necessary work as rapidly as it may be required, though of course this surplus can never be expected to pay for rebuilding and enlarging the old locks and dry-dock.

The present system of suspending the gates of this canal has proved defective. The masts, which are of wood, are decaying, and the suspension-rods are too light. The rollers do not work well, and it is almost impossible to keep the track clear for them. I believe it would be an improvement to abandon the rollers and put in iron masts with suspending-rods of a sufficient size to bear the weight of the gates. I also believe it would facilitate the movement of the gates to sink the floor of the lock-chamber just above the gates, and thus drop the sediment out of the way. I believe it also practicable to place additional wickets in a wall below the gates and thus greatly reduce the time of filling and emptying chambers. The repairs of the miter-sills of the new locks, which must be done in a few years, would afford an opportunity for also doing this work.

There are many methods of applying power to the gates, but to select the ones most simple and effective requires time and study. Using water under heavy pressure for transmitting power from some central point to the gate, presents, as a method, many advantages and but few defects. This method would be economical, requiring but few to manage it, and the machinery would all be very simple and not liable to get out of order.

The present method of removing sediment from the canal by dredging is, in my opinion, the only practicable one, and past experience has shown that, even with the poor and imperfect machinery, deposits could be removed very rapidly, in fact, almost as rapidly as navigation demanded; and with the new boats, &c., it does not seem probable that any serious delay can occur.

Sluicing out the sediment has been frequently referred to, but I do not believe it would be of much service as an auxiliary to the dredges. The sediment is principally deposited during high water, at a time when no current would be admissible, and the dredges will generally have removed a great part of this sediment by the time a fall in the river would permit sluicing out. The deposit in the locks is the most troublesome and most extensive; it is washed in from below by an eddy. Sluicing out the canal would, I think, assist but little in removing this deposit.

TABLES ANNEXED TO REPORT.

In table No. 1 the number of lockages by day includes all from 7 a. m. to 6 p. m.; and the number by night includes all from 6 p. m. to 7 a. m. Under the head of "Greatest number of lockages in one day," a consideration of the time occupied and tonnage will give the best idea of the capacity of the canal. This tonnage is proportionally greatest during coal-runs, as in March, April, and May, and the time occupied includes not only the time required for removing gates and filling chambers, but the long time required for removing boats.

The expenditures given in table No. 3 are divided into "Superintendence, management, and repairs," and "Permanent work." The first embraces the operating expenses of the canal, and will be incurred yearly; the second embraces such expenses as are permanent in their nature.

The expenses of passing boats and dredging, &c., are comparatively uniform, and the cost of work is regulated by the number of boats passed and amount of sediment removed.

The cost of dredging is low, considering the imperfect condition of dredges, &c., during a portion of the year, the many delays and interruptions, and the distance the material dredged has to be moved.

Table No. 5 gives comparative statistics for the years 1874, 1875, and 1876; 1874 only includes the time from June 11, when the Government took charge, to the end of the calendar year. It will be seen that a gradual reduction has been made in the expenses of operating the canal, the cost of this work for the year 1876 being $2,519.68 less than for the year 1875.

CONCLUSIONS AND RECOMMENDATIONS.

The past year has been very favorable, both as regards the condition of the river, the receipts from tolls, and the work accomplished, and the indications of a continued increase in the river commerce insure the maintenance, if not the radical improvement of the canal. The canal and appurtenances are now in a much better condition than ever before. The dredging apparatus is in perfect order, and the machine-shops offer ready means for repairs, &c.

I would respectfully recommend that the present system of superintendence and management be continued; that for the year 1877 the rates of tolls and charges be as follows:

TOLLS.

On steamboats and model barges, 10 cents per ton under tonnage.
On square barges, flats, coal-boats, &c., 8 cents per ton measured capacity.
Steamboats under 50 tons and flats under 63 tons, $5.
Square barges and coal-boats which have passed through the canal, returning empty, 5 cents per ton measured capacity.
On rafts of logs, &c., measurement and rates the same as for flats.
Boats belonging to the United States, free.

CHARGES.

For use of dry-dock, one day, $20; each additional day, $10.
For towing, ordinary rates of harbor-boats.
For use of dredges, $30 per day for each dredge.
For use of steam-pump on tow-boat, $2.50 per hour. Authority has already been granted for towing under certain restrictions.

Heretofore the condition of the dredges has made it necessary to keep them at work all the time in the canal, but I hope in future that deposits can be more rapidly removed. If such is the case, there will be times when the dredges will be idle, and as there are no others at Louisville, they might then do private work.

If through unavoidable accident or through any fault of the canal management a boat should sink in the canal, it would certainly be the duty of our tow-boat to render assistance free of charge; but if an accident should be caused by evident carelessness, boats responsible should be made to pay for assistance.

I would respectfully renew the recommendation and suggestions contained in my report for 1875, namely:

That the question of jurisdiction at the head of the canal be determined.

That the surveyors of customs be requested to furnish the collector of tolls with the measurement of vessels liable to pass through the Louisville and Portland Canal.

That some action be taken upon the repairs of the old locks and dry-docks.

That action be taken upon the rules and regulations for the government of the canal and those using it, suggested in reports of 1874 and 1875.

I would in addition recommend the buiding of a coal-elevator with a capacity of 1,000 tons, an office for the superintendent of the canal, and a few small cottages for the accommodation of the lock-hands. I would suggest the preparation and printing of a descriptive report of the canal, with such plates as may be required for an understanding of its various parts. During the past two years many visitors, especially foreign engineers, have called upon us, and the need of such a report and description has been felt.

In conclusion, I would state that during the year the superintendent and his assistants have performed their duties in a most faithful and efficient manner.

I am, very respectfully, your obedient servant,

A. MACKENZIE,
Captain of Engineers.

Maj. G. WEITZEL,
Corps of Engineers, U. S. A.

TABLE No. 1.—*Statement of boats passed through Louisville and Portland Canal, number of lockages, and amount dredged, for year ending December 31, 1876.*

Month.	Number and under tonnage of steamboats, barges, small boats, &c.											No. of lockages.		Greatest number of lockages in one day.					Number of days locks closed by high water and ice.	Number of days dredging in—			Number of miles run by tow-boat.	Number of cubic yards removed.		
	Passenger-boats.		Tow-boats.		Model barges.		Square barges.		Small.	Total.																
	Number.	Under tonnage.	Number.	Under tonnage.	Number.	Under tonnage.	Number.	Measured capacity.	Number.	Number.	Under tonnage.	Day.	Night.	No. of lockages.	No. of chambers.	No. boats passed.	No. of tons.	Time occupied, hours.		Canal.	Locks.	Total.		Canal.	Locks.	Total.
1876.																										
January ...	29	12,965	11	1,529	21	5,567	39	10,689	6	106	30,750	36	27	10	2	33	7,580	14	14	5	13	18	88	1,712	4,158	5,870
February ..	15	6,245	5	950	14	3,816½	12	2,570¼	2	48	13,582¼	19	8	5	2	13	3,39[illegible]	5½	19	10	7½	17½	154	4,876	2,812	7,688
March	45	17,563	22	3,797	37	9,027	172	55,819	6	282	86,206	85	35	12	1	40	13,731	11	6	14	8	22	198	5,918	2,926	8,844
April	61	23,295	35	5,811	52	13,656	249	71,963	13	410	114,727	110	51	13	1	44	13,184	16	5	17½	4¼	21¾	207	7,758	1,064	8,822
May	95	35,351	43	8,001	91	22,225	365	102,100¼	11	605	167,677½	159	111	15	1	52	16,979	18¼	0	9	16	25	203	4,268	6,840	11,108
June	97	32,136	32	6,310	67	16,465	127	30,479	6	329	85,390	97	63	12	2	29	8,40[illegible]	15¼	0	1	25	26	14	580	8,702	9,282
July	88	28,650	24	4,492	73	17,837	79	18,286	5	269	69,265	96	53	9	2	26	6,42[illegible]	12¼	0	7	2	9	85	2,044	1,224	3,268
August	91	29,691	19	3,321	37	9,530	65	13,354	6	218	57,896	75	64	9	2	18	3,767	11¼	0	24	4	28	253	12,010	2,280	14,290
September .	72	20,489	19	3,064	31	7,092	80	20,502	10	212	51,147	65	55	9	2	30	7,78[illegible]	10	0	23	0	23	286	10,426	......	10,426
October	99	34,813	26	3,152	61	14,179	88	18,539	19	292	70,683	98	56	13	2	36	9,41[illegible]	14¾	0	26	0	26	247	8,322	......	8,322
November .	103	40,633	25	4,155	77	19,808	152	32,346	36	393	96,942	108	83	12	2	40	11,19[illegible]	15½	0	23	0	23	308	5,510	......	5,510
December ..	29	13,476	6	1,001	10	2,656	46	10,093	8	99	27,226	30	20	9	2	17	2,939	9¼	15	11	0	11	130	1,558	......	1,558
Total ..	824	295,307	267	45,583	571	141,858¼	1,474	386,743½	128	3,264	871,491¾	978	626	....	...	....	......	.....	59	170½	79¾	250¼	2,173	64,982	30,006	94,998

TABLE No. 2.—*Statement of receipts of Louisville and Portland Canal for year ending December 31, 1876.*

Number.	Designation.	Number of tons under tonnage.	Price per ton.	Amount of tolls collected.
824	Steamboats	295, 307	$0 10	$29, 530 70
267	Tow-boats	45, 583	10	4, 558 30
571	Model barges	141, 858¼	10	14, 185 85
1474	Square barges	386, 743½	08	30, 939 46
128	Small boats	....	$5 each	640 00
Total receipts from tolls				79, 854 31
Total receipts from dry-dock				220 96
Total receipts from towage				275 00
Total receipts from rents				412 00
Total receipts for year 1876				80, 762 27

Balance on hand January 1, 1876	$15, 669 54
Received during year 1876	80, 762 27
Total	96, 431 81
Expended during year 1876	69, 476 21
Balance on hand January 1, 1877	26, 955 60

TABLE No. 3.—*Statement of expenses of superintendence, management, and repair of the Louisville and Portland Canal, and accessories, for the year ending December 31, 1876.*

Month.	Superintendence, management, and repair.							
	Lockage department.					Dredging department.		
	Labor.	Purchases and repairs.	Lights.	Office expenses.	Total.	Labor.	Purchases and repairs.	Total.
January	$2, 404 37	$502 95	$7 84	$20 50	$2, 935 66	$1, 087 16	$296 25	$1, 383 41
February	2, 356 33	58 99	....	24 00	2, 441 32	1, 020 00	214 05	1, 234 05
March	2, 370 00	136 55	14 83	....	2, 521 38	1, 087 14	50 74	1, 137 88
April	2, 344 00	23 60	1 50	24 00	2, 393 10	1, 028 00	465 43	1, 493 43
May	2, 333 50	37 51	8 16	14 98	2, 394 15	1, 082 00	205 33	1, 287 33
June	2, 195 00	117 92	7 68	....	2, 320 60	1, 035 34	99 65	1, 134 99
July	2, 195 00	98 90	....	32 35	2, 326 25	940 00	179 00	1, 119 00
August	2, 145 00	147 44	12 42	....	2, 304 86	940 00	412 10	1, 352 10
September	2, 209 66	173 09	16 66	....	2, 399 41	943 75	313 29	1, 257 04
October	2, 205 00	105 97	18 20	....	2, 329 17	970 66	342 73	1, 313 39
November	2, 205 00	96 45	17 34	15 40	2, 334 19	951 37	246 82	1, 198 19
December	2, 205 00	80 00	18 49	42 20	2, 345 69	940 00	169 10	1, 109 10
Total	27, 169 86	1, 579 37	123 12	173 43	29, 045 78	12, 025 42	2, 994 49	15, 019 91

TABLE NO. 3.—*Statement of expenses of superintendence, &c.*—Continued.

Month.	Permanent improvements and repairs.							
	Carpenter and machine shop.	Tow-boat.	Dredges.	Mud-scows.	Miscellaneous.		Total.	Grand totals.
January	....	....	....	$634 08	Telegraph	$384 43	$1,018 51	$5,337 [illegible]
February	$42 35	$3,041 60	....	27 95	....	....	3,111 90	6,787 [illegible]
March	117 61	....	....	10 37	Hedge	95 00	222 98	3,668 [illegible]
April	159 00	....	....	100 00	Telegraph	33 75	292 75	4,179 [illegible]
May	275 48	53 98	....	151 75	....	....	481 21	4,168 [illegible]
June	270 17	130 35	$1,208 01	....	Abstract of titles Cistern	3,000 00 329 63	4,938 16	8,308 [illegible]
July	89 00	3,063 91	333 92	15 00	Telegraph Cistern	26 3 00	3,525 09	6,970 [illegible]
August	1,549 28	1,031 65	1,038 92	....	....do	4 50	3,624 35	7,281 [illegible]
September	269 15	....	200 00	....	Mileage	45 92	515 07	4,171 [illegible]
October	56 67	....	591 73	....	....do	178 56	826 96	4,460 [illegible]
November	252 62	....	329 93	651 82	Bridge New guard-gates	541 25 3,398 83	5,174 45	8,706 [illegible]
December	9 96	....	1,523 29	140 34	Bridge	5 50	1,679 09	5,133 [illegible]
Total	3,091 29	7,341 49	5,225 80	1,731 31	....	8,020 63	25,410 52	60,476 [illegible]

TABLE No. 4.—*Statement of expenses, with cost of dredging, lockages, &c., for year ending December 31, 1876.*

Month.	Lockage department.				Dredging department.						Lockage and dredging departments combined.						
							Deductions for tow-boat earnings, &c.		True cost of dredging.								
	Monthly expenditures.	Cost per lockage.	Cost per boat.	Cost per ton under tonnage.	Monthly expenditures.	Cost per cubic yard.	Lost time.	Tow-boat earnings.	Month'y.	Per cubic yard.	Month'y expenditures.	Cost per lockage.	Cost per boat.	Cost per ton under tonnage.	Cost per bushel of coal.	Cost per ton of iron ore.	Cost per barrel of salt.
				Cents.		*Cents.*				*Cents.*				*Cents.*	*Cents.*	*Cents.*	*Cents.*
January	$2,935 66	$46 59	$27 69	9.60	$1,383 41	21.5	$408 00	$5 00	$970 41	16.6	$4,319 07	$68 56	$40 75	14.07	0.157	5.50	0.65
February	2,441 32	90 42	50 86	17.90	1,234 65	16.0	442 00	....	792 05	10.3	3,675 37	136 12	76 57	27.06	0.195	7.10	......
March	2,521 38	21 01	8 94	2.90	1,137 88	12.9	272 00	100 00	765 88	8.6	3,659 26	30 49	12 98	4.25	0.172	7.66	0.92
April	2,393 10	14 86	5 64	2.09	1,493 43	17.0	297 50	80 00	1,115 93	12.6	3,886 53	24 14	9 48	3.39	0.177	7.14	0.82
May	2,394 15	8 86	3 95	1.42	1,287 33	11.5	170 00	90 00	1,027 33	9.2	3,681 48	13 64	6 09	2.20	0.171	7.40	0.77
June	2,320 60	14 50	7 05	2.70	1,134 99	12.2	594 02	....	540 97	5.8	3,455 59	21 59	10 50	4.04	0.151	6.90	1.23
July	2,326 25	15 61	8 65	3.36	1,119 00	34.2	851 86	....	267 14	8.2	3,445 25	23 12	12 81	4.97	0.164	8.30	1.80
August	2,304 86	16 58	10 57	3.90	1,352 10	9.5	62 66	....	1,289 44	9.0	3,656 96	26 31	16 78	6.31	0.165	8.70	1.61
September	2,399 41	19 99	11 32	4.69	1,257 04	12.0	219 31	....	1,037 73	9.9	3,656 45	30 47	17 25	7.14	0.167	11.10	0.69
October	2,329 17	15 13	7 95	3.28	1,313 39	15.8	250 00	....	1,063 39	12.8	3,642 56	23 65	12 43	5.15	0.172	7.80	0.95
November	2,334 19	12 22	5 94	2.41	1,198 19	21.7	401 67	....	796 52	14.5	3,532 38	18 49	8 93	3.64	0.169	11.50	0.94
December	2,345 69	46 91	23 69	8.62	1,109 10	71.2	661 67	....	447 43	28.7	3,454 79	69 09	35 91	12.69	0.161	......	1.72
Total and averages	29,045 78	18 12	8 90	3.33	15,019 91	15.8	4,630 69	275 00	10,114 22	10.6	44,065 69	27 47	13 53	5.06	0.170	7.86	1.04

TABLE No. 5.—*Comparative statement of receipts, boats passed, work done, and expenses, Louisville and Portland Canal, fo year ending December 31, 1876.*

Year.	Monthly receipts.												Source.				
	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Tolls.	Dry-dock.	Tow-ing.	Rents.	Total.
1874	....	....	....	....	....	$2,744 85	$1,460 65	$3,[illegible]27 65	$1,249 05	$1,488 55	$1,704 08	$8,520 70	$19,606 25	$464 28	$45 00	$280 00	$20,395 53
1875	$3,015 25	$2,092 40	$1,525 76	$10,277 44	$12,935 48	7,447 07	2,864 96	3,406 81	3,715 86	3,289 32	8,225 00	11,380 26	68,664 75	599 21	350 00	561 65	70,175 61
1876	2,953 47	1,342 81	7,660 22	10,204 40	14,927 99	8,005 42	6,611 78	5,3[illegible]8 52	4,765 66	6,920 33	9,367 93	2,613 74	79,854 31	220 96	275 00	412 00	80,762 27
Total..	5,968 72	3,435 21	9,185 98	20,481 84	27,863 47	18,197 34	10,937 39	12,02[illegible] 9[illegible]	9,730 67	11,698 20	19,297 01	22,514 70	168,125 31	1,284 45	670 00	1,253 65	171,333 41

Year.	Steamboats.		Tow-boats.		Model barges.		Square barges.		Small boats.	Total boats and tonnage.		No. of cubic yards dredg'd.	No. of miles run by tow-boat.	No. of days locks closed.	No. of lockages.	Cost per ton, including total expenses managem'nt.
	No.	Under tonnage.	No.	Under tonnage.	No.	Under tonnage.	No.	Measured capacity.	No.	No.	Tonnage.					
1874	343	101,016	92	14,440	......	....	690	158,909	39	1,164	274,365	....	....	....	....	9.12
1875	647	234,248	281	44,420	593	146,517⅛	1,270	333,510⅛	90	2,881	757,695⅜	90,488	1,863.5	93	1,401	6.14
1876	824	295,262	267	45,583	571	141,[illegible]58¾	1,474	388,743	128	3,264	871,446⅛	94,988	2,173	59	1,604	5.06
Total	1,814	630,526	640	104,443	1,164	288,376	3,434	881,162⅛	257	7,309	1,904,507⅛	185,476	4,036.5	152	3,005	....

Year.	Expenses lockage department.								Expenses dredge department.							Total superintendence, management, and repair.	Permanent improvement.	Grand total.
	Labor.		Repairs.	Lights.	Forage.	General purchases.	Office expenses.	Total.	Labor.		Repairs.	Fuel.	Lubricating oil.	General purchases.	Total.			
	Regular.	Extra.							Regular.	Night-work.								
1874	$15,099 78	.....	$420 43	$44 27	$275 02	$85 80	$35 45	$15,960 75	$6,830 00	......	$459 96	$1,599 00	$106 95	$69 50	$9,065 41	$25,026 16	$115 95	$25,142 11
1875	27,720 00	$545 57	700 63	108 85	337 07	67 21	39 08	29,518 41	12,240 00	$633 19	884 22	3,053 25	186 80	69 51	17,066 97	46,585 38	3,174 11	49,759 49
1876	26,870 00	299 86	1,141 74	123 12	294 38	143 25	173 43	29,045 78	11,760 00	265 42	797 87	2,072 00	104 87	19 75	15,019 91	44,065 69	25,410 52	69,476 21
Total	69,689 78	845 43	2,262 80	276 24	906 47	296 26	247 96	74,524 94	30,830 00	898 61	2,142 05	6,724 25	398 02	158 76	41,152 29	115,677 23	28,700 58	144,377 81

APPENDIX T.

ANNUAL REPORT OF MAJOR WM. E. MERRILL, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1877.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, July 18, 1877.

GENERAL: I have the honor to transmit herewith annual reports on the works under my charge for the fiscal year ending June 30, 1877.

Very respectfully, your obedient servant,

WM. E. MERRILL,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A.

T 1.

IMPROVEMENT OF THE OHIO RIVER.

The only works of construction carried on during the fiscal year just ended have been the repair of the old dike at the Trap, a few miles below Pittsburgh, and the extension of the dike just above Evansville, Ind. Work has also been done in removing the Jackson Rock in the Grand Chain, some 20 miles above Cairo. The snag-boat E. A. Woodruff worked continuously during the low-water season, as did also the Government dredges Ohio and Oswego.

DIKE AT THE TRAP, 12 MILES BELOW PITTSBURGH.

This dike was first built in 1838–'39, and was repaired in 1844, and again in 1867. Owing to the fact that there is a heavy current across this dike at certain stages of the river, and that these stages often occur at times when the river is full of ice, it has thus far proved impossible under the old method of construction, by loose riprap, to prevent the ice from cutting down the top of the dike, and thus leaving it too low to do its proper work in maintaining the channel. I therefore determined that in repairing this dike, I would place a heavy wall of timber on the channel side, and would also raise the dike by crib-work, building it up in accordance with the usual method followed in constructing cribs for lake harbors.

The last appropriation for the Ohio did not become available until September 15, 1876, a date too late to admit of making formal contracts for work to be done before cold weather. On this account, and for the additional reason that I believed better and more satisfactory work could be done by hired labor, I recommended the latter method of working, which was approved by the Chief of Engineers.

Mr. J. V. Hoag, jr., was put in charge of repairing the dike at the Trap and directed to build it up even with the 6-foot stage in the river, this being the height desired by the coal interests. Work was begun on the 19th of October and closed on the 21st of November, cold weather rendering it impracticable to work later. During this limited time, 985 linear feet of dike was built up to a level with the stage of 6½ feet in the river, the head of the dike gradually rising 2 or 3 feet higher. Of this length of dike, 735 feet was smooth crib-work of sawed lumber, against which boats could "flank" without injury. The new work was temporarily terminated by extending the lower courses of the crib-work 72 feet farther, and ballasting them heavily with stone. The filling of the dike was blast-furnace slag mixed with riprap stone. The total amount of material used was 95,812 feet (board-measure) of lumber, 1876 cubic yards of slag, 385 cubic yards of stone, and 13,580 pounds of bolts and spikes. An additional length of 2,000 feet will probably be built up during the present summer.

EVANSVILLE DIKE, 783 MILES BELOW PITTSBURGH.

This work, which had been under construction for several years, under contract with James S. Routh, (C. B. Bateman, of Evansville, being the resident engineer,) was finally completed on the 16th of December. The total length of the dike is 2,000 feet, and its width 50 feet, except for a distance of 200 feet at the lower end, where it is but 40 feet wide. During the fiscal year the dike has been extended 500 feet, and the part previously built has been thoroughly repaired. The following is an extract from Mr. Bateman's final report on the work:

> The whole work is substantial, and fully achieves the object for which it was constructed. Steamboats now all take the channel across the bar, and with the scour anticipated this winter the channel will be fully established for all time.
>
> Soundings were taken on Wednesday last, (December 13,) with the river at 5.75 feet per gauge, and at 100 feet from shore no less than 6½ feet was found, and within 500 feet of the water-works building there was 8 feet large. Soundings along the lower side of the dike on the same day showed that a considerable amount of scour was going on along the first 1,000 feet of its length, but before that can do any harm the channel across the bar will be rendered so permanent and deep that the dike will have done its perfect work.

The total material expended on this dike from its commencement is 931 piles, 22,837 cords of brush, and 16,788 cubic yards of riprap stone. Of this, 236 piles, 7,920 cords of brush, and 7,743 cubic yards of stone were used during the past fiscal year.

JACKSON ROCK, 945 MILES BELOW PITTSBURGH.

This rock was a prominent and well-known knob of the famous four-mile reach of rocky ledges and knobs known as the Grand Chain, some 20 miles above Cairo. In extreme low water this is the most dangerous section of the Ohio River. It was probably much worse in former times than at present, as a large number of rocks were removed in 1829 and 1830 by a party working under Capt. Henry M. Shreve, at that time superintendent of Government work on western rivers. Unfortunately there is no record on file showing the condition of the chain before Captain Shreve began work, nor the state in which it was left by him.

Careful surveys of the Grand Chain were made in 1872 and 1874 by my principal civil assistant, Mr. William Weston.

From these surveys, and from information given by pilots, I concluded to attempt the removal of the Jackson Rock, and such other of the rocks

in the chain as could be operated on during low water. The greatest obstacle to work in this locality is the uncertainty as to when to expect low water. It often happens that the season passes by without the water once reaching a sufficiently low stage for successful work.

With the approval of the Chief of Engineers, I hired one of the wrecking boats belonging to the Underwriters' Wrecking Company of Cincinnati, together with her crew and outfit. Putting the boat in charge of Mr. Weston I ordered it to the Grand Chain, with instructions to begin work on the Jackson Rock. The following is Mr. Weston's report of work at the chain:

The work of removing Jackson Rock was carried on by the wrecking-boat Charley Hill, between November 8 and December 8. Fifty-four cubic yards of rock were removed from the ledge, of which Jackson Rock was the highest part. The solid rock, which was formerly bare at dead low water, is now 3 feet under water at the same stage. Along the north or Illinois side of the rock there yet remains a ridge, or reef of gravel, sand, and spalls, a part of which is only 2 feet below low water, or 1 foot higher than the solid rock. This ridge originally contained many rock-lumps, or "nigger-heads." All of these were broken up and removed, and we continued to explode torpedoes on the gravel as long as any stone large enough to injure a boat could be found in the sides of the hole formed by the explosion. In this way the reef was pretty effectually loosened up to the depth of 3 feet or more below low water, but we had no means of removing it altogether. In place of solid rock, the Jackson Rock is now a gravel-reef, or lump, with 2 feet more water on it than there was originally on the rock. This is equivalent to 2 feet at the lowest water, assuming that the top of the original rock was at the level of the low-water line. An old coal-boat wreck lies partly on the Illinois side of this gravel-ridge, and some loose plank of this wreck, which swing with the current, are a few inches higher than the reef. These, and a sand-bar that has formed below, are the highest points left, and they may make a break, or roll at low stages of water.

After repeated examinations of the river-bed, Mr. Quigley, the diver, reported that it was everywhere soft and smooth, and that there was nothing left that would injure a boat, if one should strike it. I hardly think that the current will remove any of the gravel. The depth of water on it was just about the same as reported in the lower river at the shoalest places when we were at work there. Should this depth prove insufficient, the reef must be dredged or scraped away before any more rock can be taken out. Search was made by the diver for a rock reported to be about 30 feet south of the Jackson Rock, and down stream from it, but nothing of the kind was found. The river-bottom was all soft sand for 80 feet, or as far as our lines would reach in this direction.

Soundings made in the place from which a coal-boat wreck had lately been removed by the snag-boat E. A. Woodruff showed no rocks or obstructions of any kind.

As there was no break or sign of rocks in the vicinity of Jackson Rock the wrecking-boat was taken up to Arkansas Rock. We had got nearly into position for work at this point on December 10, when the ice commenced running, and we were obliged to go to the bank. The ice continued to form, and on the 17th had become so heavy that I saw no immediate prospect of resuming the work to advantage, and so quit without doing any work at Arkansas Rock, or even having a chance to make an examination of it.

OPERATIONS OF SNAG-BOAT E. A. WOODRUFF.

In my last annual report I stated that the *Woodruff* began her season's work on the 8th of June, and I reported the results of that work up to June 30, the end of the fiscal year.

This year the snag-boat began work on the 5th of June, and is at work at the present writing. A report for the *fiscal* year would, therefore, embrace all of the work done during 1876, (except three weeks in June,) together with that accomplished in June, 1877. It is thought that such a report, containing fragments of two seasons' operations, would be less satisfactory than a report for one calendar year. I will, therefore, follow the plan adopted in preparing the tabulated statements of the work of the dredges, given in my annual reports for the last two years, and confine myself to the operations of the snag-boats for the year 1876.

The season's work began June 8, 1876, and ended November 30, 1876,

at which date the boat went out of commission in the harbor at the mouth of the Tennessee, that point having been selected for winter quarters as being the safest from danger from ice or from fire. During the season she worked over the river as follows:

1. Cincinnati to Wheeling, (could not get higher on account of low water.)
2. Wheeling to Cairo,
3. Cairo to Parkersburg, (could not get higher on account of low water.)
4. Parkersburg to Lawrenceburg, (turned back on account of high water.)
5. Lawrenceburg to Pittsburg, (waited at Pittsburg four days on account of high water.)
6. Pittsburgh to Cairo.
7. Cairo to Caseyville, and thence to winter quarters at Paducah.

The sum of her season's work was 915 snags, of an approximate weight of 7,566 tons, and 21 wrecks. The average weight of an Ohio River snag is, therefore, 8.28 tons.

The heaviest snag removed was taken out near Raleigh, Ky. It weighed 96 tons, and was pulled, cut up, and put away in 2½ hours. The most troublesome snag was the one which sunk the Arlington in Cumberland Chute. The top of this snag was about 3 feet under water, and it could not, therefore, be brought to the surface by the butting-beam, nor could it be lifted by the drag chain, as the stump was standing vertical, with its roots deeply buried in the sand. It was finally removed (after being undermined by one of the dredges then at work making a gap through the Cumberland Dam) by catching a fluke of the large grapnel in a cavity of the stump. The work of raising this monster occupied the whole of two days.

The winter of 1876–'77 was unusually destructive to shipping in the Ohio and other western rivers. Notwithstanding the selection of what seemed to be the best harbor on the Ohio, the *Woodruff* was damaged by the great ice flood. The first blow from the ice-field knocked two holes, each about 6 inches in diameter, through the outer side of her port bow. The numerous bulkheads and general water-tight construction of the hull prevented her from sinking, and the holes were speedily stopped with bedding from the boat. After all danger from ice was over the boat was brought to Cincinnati, the injured sheet was removed, and a new one was riveted in its place by the use of a side-dock, thus making the hull as good as new.

In my last annual report I stated that the boilers of the snag-boat were too far aft, and that I intended to move them forward before commencing this season's work. This was done after the boat arrived at Cincinnati by turning them around the chimneys as a center. The bows were also strengthened, double jackets were placed around the chimneys, cars were built to carry coal in the hold, and in general all the defects that were developed during last season's work were remedied as far as practicable.

The boat is now on an even keel, and draws 36 inches when loaded with 800 bushels of coal and with boilers filled with water.

The primary object of the *Woodruff* is the removal of snags, and for this work she is very complete. Her secondary work is the removal of coal-barge wrecks, of which, owing to the immense amount of coal carried on the Ohio, there is a plentiful crop every season. These are broken up by means of a huge six-fluked grapnel, weighing 1½ tons, which is attached to the chrome-steel hoisting-chain, and dropped overboard just above the barge to be wrecked. The continued dragging of this grapnel over the wreck soon tears it to pieces.

Wrecks of steamboats and of "model" barges (double-ended barges,

with steamboat bows) are too smooth and strong to be torn up by a grapnel, and the snag-boat does not therefore work at such obstructions. The only remedy for such wrecks is to employ a diver and blow them up with powder.

We are greatly hampered in endeavoring to keep the Ohio clear for navigation by the owners of wrecked barges claiming possession of them until every pound of coal has been removed, regardless of the great injury which the presence of wrecks in a narrow channel may cause to passing vessels. Last year a wrecked barge loaded with brick remained in the channel at Mill Creek Island during the whole season, greatly endangering all classes of navigation, until the owner had taken out all the brick he found it profitable to remove. Late in the season I was notified that the barge was abandoned, but the snag-boat was then below Louisville, and soon after went into winter quarters.

This wreck was not removed until June 20 of the present season, and therefore it obstructed the channel for over a year.

This year I gave public notice in the newspapers that all wrecks would be considered as abandoned unless I was notified to the contrary. Many notices were sent to me, all of which have been respected. A few days ago, however, a claim was made on me by a prominent coal firm of Pittsburgh for the value of a barge which had been torn up by the snag-boat, on the ground that the barge had not been abandoned, although no notice to that effect had been received either at this office or at the snag-boat. The barge in question was carried out of the Monongahela in the ice-flood of last January, and was sunk at Middle Island, 152 miles below Pittsburgh. It had, therefore, lain a wreck for 5 months, and had already caused the destruction of another barge. It was a very serious obstruction of which all the pilots complained. Careful inquiry by the captain of the snag-boat in the neighborhood of the wreck failed to discover any act of the owners indicating that they still maintained a claim to the barge, and it was therefore broken up and removed from the channel. The owners of the barge now claim that the United States should pay them $1,000 for this barge, asserting that it was worth $1,200, and that its removal would not cost more than $200, besides the value of the coal it contained.

In view of these facts and for the protection of commerce, as well as of the officers of the Government who are trying to keep the great navigable rivers free from obstructions, I would earnestly renew the recommendations contained in my annual report for 1873, and I therefore quote from it the following as the draught of a much-needed law:

AN ACT to preserve the free navigation of the rivers and harbors of the United States.

Be it enacted, &c., That from and after the passage of this act it shall be lawful for persons in charge of works of improvement carried on under the authority of the General Government in any of the rivers or harbors of the United States to remove any stranded or wrecked boats or barges, or any other obstruction which may interfere with the free navigation of such rivers and harbors: *Provided*, That the work of such removal is not promptly begun and vigorously prosecuted by the owners of such boats, barges, or obstructions. In case of such removal by the agents of the General Government, the cost of removal shall be a lien against the things removed. All property saved by the United States from wrecks that have been abandoned by their owners is hereby declared the property of the United States, to be disposed of as may be directed by proper authority.

DREDGING.

The United States dredges Ohio and Oswego were continuously at work in the Ohio River from before the beginning of the fiscal year until November 30. At the latter date they were sent up the Wabash

(at that time under my charge) to do some much-needed work at the Little Chain. The record of their work on this river will be found in the annual report of Maj. Jared A. Smith, to whom I transferred the charge of the Wabash on the 22d of January, 1877. The dredges returned to the Ohio on the last of February, and at once proceeded to Cincinnati for their annual spring overhauling and repairs.

In the spring of 1876 the *Ohio* was furnished with a wrought-iron crane, experience having shown that the work required on the Ohio River was too heavy for wooden cranes. This new crane has worked admirably, and with the permission of the Chief of Engineers, the *Oswego* has also been supplied with an iron crane. The most serious cause of accidents and resulting loss of time and expensive repairs has thus been removed.

RACCOON ISLAND, 273 MILES BELOW PITTSBURGH.

The beginning of the fiscal year found both dredges at this place removing a lump between the two channels at the head of the island. On July 20 the work was nearly finished, 16,970 cubic yards having been removed during the month, (6,940 cubic yards had been removed in June,) when the dredges were ordered up the river to White's Ripple, 11 miles below Pittsburgh.

DEADMAN'S ISLAND, 14 MILES BELOW PITTSBURGH.

The dredges were suddenly ordered to this end of the river on account of serious complaints from the Pittsburgh Coal Exchange that while dredging at Kay's Bar and White's Ripple (substantially the same place) earlier in the season, a dangerous lump had been left in the channel. The dredges were stopped at Deadman, 3 miles below White's, to remove a new shore-bar thrown out by Little Sewickley Creek, and to give Mr. Carpenter, the assistant engineer in charge of dredging, an opportunity to find the lump complained of at White's. A careful examination, made in conjunction with leading coal operators and pilots, showed that no work at White's was needed, and the dredges, therefore, remained at Deadman. Work was much hindered by low water, and during a part of the time when the dredges were unable to work the crews were employed in building a small dam of brush and stone across the mouth of Little Sewickley Creek, so as to throw the current and deposits into the pocket below the shore-bar, and prevent the continual obstruction of the channel. This little dam has thus far accomplished its purpose admirably. Excavation made, 16,080 cubic yards.

FISH CREEK ISLAND, 113 MILES FROM PITTSBURGH.

On completion of the work at Deadman the dredges went to Fish Creek Island, and removed a lump between the two channels of the river, completing the work October 11. Excavation made, 25,345 cubic yards.

CAPTINA ISLAND, 109 MILES FROM PITTSBURGH.

Work was begun here on the 12th, and continued until the 21st of October, when the dredges started for Cumberland Dam. Excavation, 7,830 cubic yards.

MATAMORAS, 141 MILES BELOW PITTSBURGH.

The dredges removed the wreck of a coal-barge from the channel at this place.

CUMBERLAND ISLAND, 908 MILES FROM PITTSBURGH.

Serious and repeated complaints were made by the river interest during the summer and fall of 1876, that the effect of the dam across the Ohio at the head of Cumberland Island was to make this point occasionally the shoalest below Louisville.

This dam was begun in 1832, and partly finished. It was repaired in 1839, and again in 1854. It was repaired and finally completed in 1872, '73, and '74, the latter work having been done under my direction. The repair of this dam was directly ordered by Congress in accordance with a report made by me on February 14, 1872. At the time of making this report I understood from the old records that the dam had always worked satisfactorily when in good repair, and that the only problem, therefore, to be solved was to make it stand the water-pressure. Believing that this could be done I so reported, and Congress ordered the repairs to be made.

These repairs were a practical success, as the dam, with some slight additional repairs of weak points, substantially held its own. The result, however, was a failure, from the fact that the natural current in high and moderate stages is across the dam, while at such stages an eddy is formed in the chute at the head of the island, causing it to fill with sedimentary deposit. As the water falls the dam begins to force a current through the chute and to remove the deposits. If the river subsides so rapidly as not to allow time for the current to cut out a channel, or if the scouring action is suddenly stopped and the deposits are remade by a flood from the Cumberland, low water comes on before the chute channel has been cut out, and thus boats find no passage either through the chute or over the dam. I am now satisfied that the reason why no record remains of such troubles in former times is that they never lasted long, being speedily terminated by the rupture of the dam. The success of the recent repairs brought into prominence the defect in the original design of the work. For a fuller statement of the reasons for the original construction of this dam, showing also why it proved defective, see Report of the Chief of Engineers for 1876, Part II, page 22.

There was no remedy for this state of affairs, except to remove the dam, or at least to make a wide opening in it. On a full statement of the case, authority was granted by the Chief of Engineers to make a gap in the dam, and it was for this work that the dredges were ordered there. Work was begun November 3, about 75 feet from the shore of Dog Island, and the gap was extended thence toward the Kentucky shore for a distance of 420 feet, being 20 feet wider than the channel span of the Newport and Cincinnati Railway bridge. The stone was removed to a depth of 2 feet below low water. A portion of the stone was placed on the dam at each end of the gap thus clearly defining it at any stage of water below 20 feet, at which depth there will be sufficient water to cross the dam at any point. The work was completed on November 27, and the dredges at once started up the river, reaching the mouth of the Wabash on the 30th.

The material handled at Cumberland Dam consisted of 10,011 cubic yards of loose stone and 1,777 cubic yards of sand. No part of this was

loaded on scows, it being deposited by the dredges either on the dam or in the deep water above and below it.

The dredges remained in the Wabash River from November 30, 1876, until the last of February, 1877, when they returned to Cincinnati, remaining here until June 25, at which date they started up the river for Raccoon Island.

In June, before the regular season's work was begun, the *Ohio* removed a wrecked barge lying at the foot of Ludlow street, Cincinnati, and made one trip to the Southern Railroad Bridge to remove a snag reported to be there, but which could not be found.

TABULATED STATEMENT.

The following tabulated statement shows the work of the dredges, and the cost of the same, for the calendar year 1876:

1876.	Miles from Pittsburgh.	Place.	Kind of work.	Days of work.	Excavation.				Expenditure.			
					Sand, gravel, &c., cubic yards.	Loose rock, cubic yards.	Cubic yards, per day of work.	Cost per cubic yard.	Total for ordinary dredging.	Total for dredging loose rock.	Total for wrecking.	Grand total.
May	4	Brunot's Island	Wrecking	1							$178 06	$178 06
Do	10	Hays's Bar	Dredging	13	12, 654		997. 4	$0 18. 3	$2, 314 80			2, 314 80
May and June	14	Deadman's Island	do	15	15, 330		1, 022. 0	17. 4	2, 670 92			2, 670 92
June	10½	White's Ripple	Loose-rock excavation	2		333	162. 5	1 07. 0		$356 12		356 12
Do		Crow Island	Wrecking and snagging	1							178 06	178 06
Do	29	Raccoon Bar	Wrecking	½							89 03	89 03
Do	35½	Phillis Island	Wrecking and snagging	½							89 03	89 03
Do		Brown's Island	Wrecking	½							89 03	89 03
Do	67	Steubenville, Ohio	Wrecking and snagging	1							178 06	178 06
Do	127	Fishing Creek	do	½							89 03	89 03
June and July	273	Raccoon Island	Dredging	21	23, 910		1, 138. 6	16. 0	3, 739 30			3, 739 30
July, August, and September	14	Deadman's Island	do	22	16, 080		730. 9	24. 3	3, 917 36			3, 917 36
September	16	Big Sewickley Creek	Wrecking	1½							267 10	267 10
September and October	113	Fish Creek Island	Dredging	20	26, 345		1, 317. 3	13. 5	3, 561 20			3, 561 20
October	109	Captina Island	do	9	7, 830		870. 0	20. 0	1, 602 55			1, 602 55
Do	141	Matamoras, Ohio	Wrecking	½							89 03	89 03
November	907	Cumberland Dam	Loose-rock excavation	21	1, 777	10, 011	561. 3	31. 7		3, 739 29		3, 739 29
Total				130	103, 926	10, 344			17, 806 13	4, 095 41	1, 246 43	23, 147 97

DREDGES IN COMMISSION DURING 1876.

Time.

Ordinary dredging, days	100
Loose-rock excavations, days	23
Wrecking and snagging, days	7
Work on Wabash River, days	15
Lost:	
Traveling, days	24
Accidents, days	16
High and low water, days	19
Sundays	32
Total	236
Total on Ohio River	221

Work

Cubic yards of gravel, &c., excavated during the season	103, 986
Cubic yards of gravel, &c., excavated per working day	1, 039
Cubic yards of loose rock excavated during the season	10, 344
Cubic yards of loose rock excavated per working day	450
Number of wrecks removed	10
Number of snags removed	7

Cost.

Equipment:	
For the season	$616 96
Per working day	4 57
Per day in commission	2 79
Towing:	
For the season	8, 493 00
Per working day	62 91
Per day in commission	38 43
Salaries:	
For the season	10, 045 94
Per working day	74 41
Per day in commission	45 45
Repairs:	
For the season	696 83
Per working day	5 16
Per day in commission	3 15
Cost:	
For dredging	17, 806 13
For loose-rock excavation	4, 095 41
For wrecking and snagging	1, 246 43
Per working day	178 06
Per day in commission	108 77
Per cubic yard gravel, &c	17.1
Per cubic yard of loose rock	39.6

DREDGES OUT OF COMMISSION DURING 1876.

Time.

In ordinary, days	99
Annual spring repairs, days	40
Total	139

Cost.

Total in ordinary	$4, 195 65
Per day in ordinary	30 23
Annual spring repairs	3, 370 08

The contract price for towing was $38 per day, Sundays excepted, with no deductions except when tow-boat was unfit for duty. Under the charter she was to furnish the dredges with coal without additional charge. Occasionally an extra tow-boat was hired for a few days. This expense is included under "Towing."

It is proper to state that the necessity of abandoning the work at Raccoon Island to go up to White's and Deadman, and the subsequent necessity of going down to Cumberland Island, which is only 60 miles from the mouth of the river, added considerably to the cost of dredging in 1876. The distance between the extreme points at which the dredges worked is 903 miles.

MOVABLE DAM AT DAVIS ISLAND.

Since my last annual report the legislature of Pennsylvania has passed an act ceding jurisdiction over the land which may be purchased for this work. Without such action on the part of the State the work could not be begun.

The act reads as follows:

AN ACT to grant the consent of the State of Pennsylvania to the acquisition by the United States of certain lands within the State and bordering on the Ohio, Monongahela, and Youghiogheny Rivers, for the purpose of erecting thereon dams, abutments, locks, lock-houses, offices, and necessary structures for the construction and maintenance of slack-water navigation on said rivers, and ceding jurisdiction over the same, and for imposing fines and penalties for willful injuries to the grounds, buildings, and appurtenances acquired under the provisions of this act.

SECTION 1. *Be it enacted by the Senate and house of Representatives of the Commonwealth of Pennsylvania in general assembly met, and it is hereby enacted by the authority of the same,* That whenever the United States shall begin the improvements of the Ohio, Monongahela, and Youghiogheny Rivers by means of locks and permanent or movable dams, or dams with adjustable chutes, the consent of the State of Pennsylvania, through the governor thereof, is hereby given to the acquisition by the United States, by the purchase or by condemnation in the manner hereinafter provided, of any lands, buildings, or other property necessary for the purpose of erecting thereon dams, abutments, locks, lock-houses, chutes, and other necessary structures for the construction and maintenance of slack-water navigation on said rivers; and the said United States shall have, hold, use, and occupy the said land or lands, buildings or other property, when purchased or acquired as provided by this act, and shall exercise jurisdiction and control over the same concurrently with the State of Pennsylvania.

SEC. 2. If the United States shall determine to take lands, buildings, or other property necessary for the purposes mentioned in the first section of this act, and cannot agree with the owner or owners of such lands, buildings, or other property, for the compensation to be made for such taking, the court of common pleas having jurisdiction in the county where such lands, buildings, or other property are situated, shall, upon application by either the United States or the owner or owners, or any one in behalf of either, shall appoint three disinterested freeholders, who, having duly qualified before said court, and having given such public notice, and such notice to owners of the premises to be reviewed and appraised, of the time and place of meeting as the said court may direct, shall ascertain and determine the amount of compensation to be paid to such owner or owners, who shall make reports to said court of their award on or before the first day of the term next after their appointment.

Provided, That the said United States shall not be authorized to take possession of, or use or occupy, the lands, buildings, or other property taken under the provisions of this section, until the amount of said award shall be paid to the owner or owners thereof: *Provided further,* That the said court may set aside the report of said viewers, upon being satisfied that the amount of said warrant is excessive or insufficient: *And provided further,* That upon the application of any party aggrieved, made within thirty days after the filing of the report of the viewers, for an issue to try the facts in controversy between the respective parties, and to determine the amount of compensation due for property condemned and taken, or for property injured or destroyed by the construction or enlargement of the works and improvements contemplated by this act, it shall be the duty of said court to award said issue, and any appeal taken pursuant to this act shall be signed by the party or parties taking the same, or by his or their agent or attorney, and shall be accompanied by an affidavit of the party appellant, or by his or their agent or attorney, that the same is not taken for the purpose of delay, but because the affiant firmly believes that injustice has been done.

SEC. 3. That if any person or persons shall willfully or maliciously injure any of the lands, buildings, or other property acquired or held under the provisions of this act, such person or persons shall be liable to a fine of not less than twenty dollars, and to an imprisonment not exceeding six months, or both, or either, at the discretion of the court, said offense to be prosecuted and punished in any court of competent jurisdiction.

E. REED MYER,
Speaker of the House of Representatives.
JNO. C. NEWMYER,
President pro tempore of the Senate.

Approved the seventeenth day of March, anno Domini one thousand eight hundred and seventy-seven.

J. F. HARTRANFT.

The United States district attorney at Pittsburg has been for some weeks engaged in an endeavor to procure the land necessary for the lock and dam at Davis Island, but at this writing he has not completed his labors. The plans for constructing the lock are all ready, and work will probably be begun before this report reaches Congress.

SPECIAL SURVEYS.

The following resolution was passed by the House of Representatives on March 2, 1877:

Resolved, That the Secretary of War be requested to report to Congress on the best methods, by harbors of refuge or otherwise, of protecting the river commerce of Cincinnati from floes of ice in the Ohio.

The duty of preparing the report contemplated by this resolution has been assigned to me, and the necessary preliminary surveys are now in progress.

In compliance with resolutions of the House of Representatives, dated January 17, 1877, and January 30, 1877, I reported on Mill Creek as a harbor of refuge, (report printed as Ex. Doc. 34, H. of R., 44th Cong., 2d sess.,) and also on Mill Bottom, Kentucky, opposite Cincinnati, for the same purpose, (report printed as Ex. Doc. 39, Senate, 44th Cong., 2d sess.)

ESTIMATE.

The estimate submitted in my last annual report for the lock and movable dam at Davis Island, including permanent dam behind the island, was $465,000. In this sum nothing was included for the purchase of land. Inasmuch as this land will all be purchased in a few months it will perhaps be better not to submit an estimate of its cost, but simply to add its actual cost to next year's estimate.

Thus far $100,000 has been appropriated for the movable dam, leaving $365,000 still necessary in addition to the cost of the land.

The cost of running the snag-boat and the two dredges for one year will be $60,000.

For riprap dams, office expenses, and contingencies, I would request $100,000.

ESTIMATE FOR 1878–'79.

For snag-boat and dredges one year	$60,000 00
For riprap dams, office expenses, and contingencies	100,000 00
For movable dam at Davis Island	365,000 00
Total	525,000 00

Money statement.

July 1, 1876, amount available	$117,020 95	
Amount appropriated by act approved August 14, 1876	175,000 00	
		$292,020 95
July 1, 1877, amount expended during fiscal year	110,577 59	
July 1, 1877, outstanding liabilities	6,924 00	
		117,501 59
July 1, 1877, amount available		174,519 36
Amount that can be profitably expended in fiscal year ending June 30, 1879.		525,000 00

T 2.

REPORT OF BOARD OF ENGINEERS ON OHIO RIVER IMPROVEMENT.

CINCINNATI, OHIO, *February* 23, 1877.

GENERAL: The Board of Engineer Officers appointed by Special Orders No. 15, dated Headquarters Corps of Engineers, Washington, D. C., February 14, 1877, met at Cincinnati, at 10.30 a. m., February 20, 1877.

Having examined and discussed the questions involved in the proposed improvements of the Ohio River, as presented for their consideration by the accompanying letter of instructions of the Chief of Engineers, dated February 14, 1877, (appended and marked B,) they have now the honor to submit their views thereon in the following

REPORT.

During the lowest stages of water the Ohio is not navigable by steamers of ordinary draught; in fact, it is scarcely navigable at all above Wheeling for minimum draught steamers without freight.

The annexed tabular statement (appended and marked "A") shows the number of days that the river ranges from 6 feet to 3 feet at Pittsburgh and Wheeling.

For many years attempts have been made with partial success to remove bars or shoals in the river by the construction of wing-dams and by dredging. This method of improvement is still being carried on by the United States Government. It is the opinion, however, of civil engineers as well as of officers of the Corps of Engineers that radical improvement can be effected only by some system of slack-water navigation, that is, by locks and dams. The best system of this kind, if it can be applied with success, is that which permits the removal at pleasure of a portion of the dam formed of movable wickets, and this method of improvement has been proposed for the Ohio River. To test its applicability, Major Merrill, in charge of the Ohio River improvement, in his annual report of 1874, recommended that a lock and dam with Chanoine wickets for the Pass should be constructed across the river about six miles below Pittsburgh, and $100,000 were appropriated by the act approved March 3, 1875, to commence the structure for trial.

It seems, however, that the Pittsburgh Coal Exchange and the Steamboatmen's Association are opposed to this system of improvement, and are strenuously exerting themselves to prevent the commencement even of the trial-dam. They have submitted a memorial to the Congress of the United States, protesting against its construction, with an accompanying report setting forth their reasons therefor under various heads. This memorial and report have been submitted to the Board with instructions to examine into the objections urged against the system by the gentlemen of the above named associations and to give their views thereon.

Taking up the line of argument essentially in the order followed in their report, we readily acknowledge that the "*tow-boat and barge system*" is an admirable one for the transportation of bulky materials, and that the "*combining tonnage in fleets*" results probably in "*the cheapest transportation in the world*," and that "*cheap transportation*" is a material element in the growth and prosperity of the Ohio and Mississippi Valleys.

"GREAT THROUGH LINES AND WAY LINES."

The memorialists, under the head of "great through lines and way lines," state that—

As the barge fleets, convoyed by tow-boats, must, in the nature of things, constitute the great through lines upon the navigation, all attempted improvements of the Ohio should be so contrived as to increase their safety and expedite their voyages. This is undoubtedly the true policy in the management of our attempted river improvements, and nothing of a different character should be permitted to be done in behalf of single freight and passenger steamboats, because from railroad competition their occupation in this quarter seems to be nearly gone, their business dwindled to comparative insignificance, and their numbers diminished to a small fraction of their former multitude. This decadency leaves their future no better promise than the way business between the towns and villages along the river shores, and the navigation of the streams flowing into the Ohio.

If it be true that transportation on the Ohio other than by "*combining tonnage in fleets*" has become insignificant, then the system of improvement of the river should be made with the view to facilitate that kind of transportation; but if there are important interests connected with the various large towns and cities along the river from Pittsburgh to Louisville which would be fostered by a system of improvement that would make the river navigable throughout the year to passenger and freight steamers of ordinary draught, those interests also demand consideration. Though the quantity of coal carried from Pittsburgh down the Ohio is very large, amounting in value to about $6,000,000 a year, other freights of export and import much exceed that of coal in value. Besides, there is a large commerce connected with other large towns and cities of the Ohio, which is carried on by freight-steamers. Though we have no means of estimating this accurately, yet, from data accessible, we doubt if the coal shipped much exceeds 5 per cent., in money value, of all other kinds of freight transported on this river. It would seem, therefore, that the coal-transportation interest of Pittsburgh is in no way entitled to dictate the system of improvements for the Ohio to the exclusion of all other interests. However, when fairly and impartially discussed and thoroughly appreciated, it will probably be admitted that the proposed system of improvement of the Ohio will be beneficial to the coal-trade as carried on by "*combining tonnage in fleets*" as well as to that effected by single steamers carrying freight or towing one or more barges.

The memorialists further state that, having canvassed "with studious care the new plan for the river improvement, they are constrained * * * to express their unqualified dissent from the same, and their undoubting belief that this plan, if carried out, would utterly ruin and annihilate the entire towing system now working so beneficially on the Ohio." They assign their reasons therefor as follows:

MONONGAHELA NAVIGATION.

There are but four locks and dams on the Monongahela which the Ohio transporters have occasion to use. It costs one cent a bushel to pass coal through these, including lockage, which constitutes one-third thereof, which sum, be it remembered, is for passing 60 miles only, from Brownsville down to this city, while it costs no more to transport coal from Pittsburgh to Louisville, a distance of 600 miles, by the present towing-system, notwithstanding that the river between the two latter places is already obstructed by bridges to a very serious extent, increasing the cost of transportation as well as the dangers of navigation. At the same rate, it would cost 10½ cents to pass 46 dams to Cincinnati; and to get through these, and the 6 additional proposed dams between Cincinnati and Louisville, making 52 locks in all, the cost would be 12½ cents per bushel, or $3.37 cents per ton. It is scarcely necessary to add that the river commerce could not exist under such a heavy imposition.

To this statement we reply that the cases are not parallel. The locks on the Monongahela are small, the standard size being 190 by 50 feet. As originally built, there was but one lock to a dam, but the gradual increase of business required a corresponding increase in lock-accommodation, and therefore an additional lock was added to each of the two lower dams, its dimensions of chamber being 250 by 56 feet. The old locks can only pass 2 barges at a lockage, and the new locks can pass the same together with a small tug. The passage of 10 barges, therefore, requires 5 lockages.

The proposed Ohio River lock will be so large as to pass these 10 barges with their tow-boat at *one* lockage. As the cost of working large river-locks ought not to be much greater than the cost of working small ones, it is evident that a correct comparison would put the cost of passing one Ohio River lock at little over one-fifth the cost of passing one Monongahela lock. If, however, we take into account the fact that the Monongahela dams belong to a private corporation which makes a profit on its investment, it is evident at once that the Ohio River locks could be kept up by tolls much smaller than one-fifth of those charged on the Monongahela.

It is therefore apparent that the statement of probable tolls to Cincinnati of 10½ cents per bushel, and to Louisville of 12½ cents per bushel, is greatly exaggerated, and in case the locks are largely used the expense will probably not be more than one-tenth of that above stated.

But the coal-fleets may, and probably will, go down the river after the construction of the dams, as they do now, on the high stage of water and not through the locks. As dues are not required of boats that pass over the falls at Louisville, it is probable that none will be required on the Ohio River when the boats do not use the locks. The advantage of locks is this: that in low stages of the water coal can be carried to manufacturing towns on the river below Pittsburgh in case of need. At times, some manufacturing establishments have been compelled to stop for the lack of coal, the supply of which failed on account of the long continuance of the low stage of water in the Ohio.

The passes contiguous to the locks are to be 400 feet wide, and well marked out by night as well as by day. As the approaches to the passes will be in the line of the channel, and as the coal-fleets are usually but 100 feet wide, though very exceptionally reaching a width of 150 feet, we believe that they will not be endangered in passing through them. This passage will be far safer than that of any railroad-bridge above Cincinnati. The channel-spans of these bridges vary from 300 to 400 feet, but there are no guides into these openings, and the currents through them are variable, sometimes setting on one pier, sometimes on the other.

"ITS LIABILITY TO ACCIDENTS."

There is little similarity between the Monongahela dams and those proposed for the improvement of the Ohio. The former are permanent, giving a system of transportation by lockage alone. The latter permit open navigation for high stages of water, during which most of the bulky freight, such as coal, will be transported, and form a lockage system only for that portion of the year when the low water would not permit its transportation at all. The destruction of a permanent dam stops navigation at all seasons until it is rebuilt. Injury to a wicket can be readily repaired, and at the worst its repair simply delays transportation for a short time. Experience in France shows that no serious troubles have been caused by accidents to similar dams.

"EFFECTS OF THE LOCK AT LOUISVILLE."

The heading of this paragraph would seem to intimate that there is but one lock at Louisville, and that all the delay and expense at this place are caused by this one lock. The truth is, that the Falls of the Ohio at Louisville are passed by a canal 85 feet wide and 2 miles long, with two outlets at its lower end. The old outlet enters the river by a flight of *three* locks, and the new outlet by a flight of *two* locks. These locks overcome a fall in low water of 26 feet, or more than four times as much as will be overcome by an Ohio River lock.

The delay at the Louisville and Portland Canal is due to its length, its comparative narrowness, (85 feet,) its great fall, (26 feet,) and the fact that the locks are in flights without any intermediate basin. The result of this arrangement is that a steamboat must pass through both locks of the new outlet, or through all three locks of the old outlet, before another steamboat can enter. This plain statement of facts should suffice to show that the argument based on experience in this canal is fallacious.

The statement is made that during high water "there may be fifty tow-boats" waiting at Louisville at one time. It is sufficient to state in reply that in the last annual report of the Chief of Engineers (Report of Chief of Engineers, 1876, vol. 1, p. 760) Captain Mackenzie, Corps of Engineers, the officer in immediate charge of the canal, in explaining the cause of delays in passing through the canal, uses the following language:

Frequently there are as many as *four* or *five* tows, with from 15 to 20 boats each, waiting to pass down through the canal, and, at the same time, passenger-boats and upward-bound tows pressing their claims.

The Board are therefore compelled to conclude, from this official record, that the assumed simultaneous presence of 50 tows at the Louisville and Portland Canal is a great exaggeration.

Were there a continuous system of movable dams on the Ohio River, it is evident, in the first place, that there would be no rush, as the existence of a perpetual navigation would make it unnecessary, and, in the second place, if tows descended during the low water they would naturally and inevitably pass through the first lock in succession, and a regular order of arrival at all the locks would thus be established, in consequence of which but one tow at a time would reach a lock.

PURCHASED BY GOVERNMENT AND TOLLS REDUCED.

This lock, let it be remembered, has been purchased by the Government, and is worked by its agents. A toll of 8 cents a ton on the tonnage of every passing craft, with an additional 2 cents upon steamers and model barges, is charged to keep the work in repair and pay the current expenses. Five cents a ton was the first charge when the Government took possession, but being found inadequate to meet current expenses and repairs, the present rates were established, which cost each tow-boat with her tow from \$600 to \$800 a single passage. Twenty-four men, besides four or five mechanics, are required to manage the lock. Is it probable that the proposed new locks, chutes, and dams can be operated with fewer men or at a less expense, or that an equal charge will not be necessary at each dam? for the whole force will have to be constantly on hand and under pay, whether the chutes are up or not. But suppose the necessary charge to be but one-half, or 5 cents per ton on the tonnage of all passing craft, the passage at this rate through 68 locks would tax the towing system upon the Ohio out of existence.

This paragraph is not correct in many particulars. The tolls on the Louisville and Portland Canal for passing through 2 miles of canal and 2 or 3 locks, are unquestionably 8 cents per ton on coal-barges, but this

is levied on the registered "under-tonnage," (determined by technical custom-house rules,) which is only about one-half the carrying capacity. Captain Mackenzie, in the report just cited, states (p. 762) that the toll on coal is about $\frac{1}{8}$ of a cent per bushel.

The memorialists conclude that the passage, at the rate stated by them, viz, 8 cents per ton for a single lock, "through 68 locks, would tax the towing system of navigation upon the Ohio out of existence."

The answer to this is clear.

The premises on which the memorialists reason are inaccurate. The canal and locks at Louisville, as before shown, are equal in lift to 4 of the proposed Ohio River locks, and if it costs $\frac{1}{6}$ of a cent per bushel to pass the Louisville locks and canal, it will cost a little less than two cents a bushel to pass 46 locks between Pittsburgh and Cincinnati, and a little more than 2 cents to pass the 52 locks to Louisville. But the officer in charge of the Louisville and Portland Canal thinks that the rates there will soon be reduced to three-fourths or one half of the present amount. If reduced to one-half, the corresponding rates to Cincinnati and Louisville would be about 1 cent per bushel. If this tax were put upon all the coal shipped, it would amount to $750,000 a year; enough to pay the running expenses of all the proposed Ohio locks.

REMARKS ON THE MOVABLE CHUTES.

It is urged by some inexpert observers that in high-water the chutes will be lowered and the tows will pass without hinderance, thus insuring a cheap and unobstructed navigation. This might occur, more or less, in the downward passage. But most of the difficulties and delays which embarrass the passage at Louisville would have to be encountered by the returning fleets, with or without freight, owing to the short duration of the Ohio floods. But even if the water remained high, the upward-bound towboats, with their numerous attachments, could not stem the rushing current through the chutes. This supposed high-water condition, however, would be of rare occurrence to the returning fleets; usually they would find the chutes raised and the locks their only method of passing the dams, and a most tardy one it would be when from 500 to 1,000 boats and barges were on their return voyages, using the locks at every dam.

We are of opinion, as before stated, that the passage down the Ohio of the coal-fleets at high stages of the river will not be essentially interfered with by the system of improvement proposed. There seems to be some force in the objection made by the memorialists that the returning coal-fleets will be impeded in their progress if compelled to use the locks, and that if the height of the river permits its open navigation, the wickets of the dams being down, the increased rapidity of the current at the passes will retard the ascent of these returning boats. These objections, however, are not as forcible as they appear at first view. For—

First. As a rule, coal-boats are not brought back. Coal-barges, only, return to the starting point.

Second. As the alternations of high and low water are rapid, often occurring in the same month, great difficulties and delays are frequently encountered by returning coal-fleets at low stages of water by reason of bars and the rapid currents at narrow portions of the river, so much so, that a slack-water navigation, with a scarcely noticeable current, and with but one lock for every 10 miles, would doubtless be more rapid than the open-river navigation against a rapid current.

Since the introduction of slack-water navigation experience on the Monongahela shows that the time of passing up the river to Brownsville has been reduced at least one-third.

We do not see any necessity for, or even probability of, a large number of returning coal-fleets so congregating as to reach a lock at the

same time. After this system of improvement is established the coal-fleets will doubtless move successively, so as not to interfere with one another, knowing that their return cannot be prevented by any fall of the river, however low.

There will doubtless be some increase in the velocity of the current contiguous to the locks when the passes are open that will somewhat impede the returning fleets in getting through them. But the length of these passes is short, and the obstruction occasioned by their increased current is not as great as at many places in the river where the navigable waters are much reduced in width, giving rapid currents for distances varying from 100 yards to 1 mile. At the Trap, 11 miles below Pittsburgh, the channel is only about 230 feet wide for a length of about 1 mile.

While acknowledging, however, the force of this objection to a limited extent, this Board do not think it sufficient to militate against a system which will be so advantageous to all interests on the river, giving a navigation for boats of large draught during the whole year, and affording to the coal-fleets an assured means of returning at low stages of water.

They would remark that the sills of the passes are to be placed so low that no boat can touch them that can go over the controlling shoals in the river.

Confining themselves to their instructions, this Board have not intended to express any opinion as to the general question of improving the Ohio, but have restricted themselves to giving their views as to the objections to the systems proposed, as set forth by the Coal Exchange and the Steamboatmen's Association of Pittsburgh, in their memorial to Congress of December 23, 1875.

As before stated, we think that one interest alone, namely, that of persons engaged in transporting coal from Pittsburgh, should not, by its opposition, prevent the trial of the proposed dam if the other important interests of that city and of the river cities and towns, many times more valuable, are in favor of it. So far as we are informed, the memorialists are the only persons who oppose the construction of the dam.

Respectfully submitted.

Z. B. TOWER,
Colonel of Engineers, Bvt. Maj. Gen.
H. G. WRIGHT,
Lt. Col. of Engineers, Bvt. Maj. Gen.
G. WEITZEL,
Major of Engineers, Bvt. Maj. Gen.
WM. E. MERRILL,
Major Engineers and Bvt. Colonel.

F. A. MAHAN,
First Lieut. Engineers, Recorder.

In signing the above report, I desire to add, that if I had been called upon to make an individual reply to the memorial of the Pittsburgh Coal Exchange, my statements would have been considerably stronger than those contained in the foregoing, and I therefore feel it necessary to remark that I see no reason to modify or retract anything contained in my annual reports in regard to the proposed movable dam at Davis Island.

The opinion of engineers is almost unanimous that a constant navigable depth in the Upper Ohio can only be obtained by the construc-

tion of dams in the bed of the river. My predecessor, Mr. W. Milnor Roberts, recommended permanent dams. I fully agreed with him until I learned of the great improvements recently made in France, by constructing movable dams. The change, therefore, from permanent to movable dams is merely a step in advance.

When I first recommended the general adoption of movable dams, no opposition to this method of improvement appeared. Since the Coal Exchange have begun to oppose them, I have limited myself to recommending the construction of *one* dam at Davis Island, in order to test the applicability of the system. I still think that the opponents of this dam do not thoroughly understand either its construction or its operation in practice, and that when it is built their opposition will cease.

Should experience, the only safe teacher, show that this dam is really an injury instead of a benefit to commerce, the river can be restored to its natural condition by simply removing one small pier, at a cost of less than $1,000. Everything else can remain as it is. The lock-wall will be a great advantage in guiding fleets into the narrow pass immediately below the dam known as "Horsetail," which is only 300 feet wide, and through which all fleets must now pass except in very high water. Nothing connected with the navigable pass need be removed as, if it be left open, no boat that can pass over the bars above and below will be able to strike its sill or its wickets.

It is very easy to urge theoretical objections to movable dams, and to suppose extraordinary accidents. This is precisely what was done in France before the movable dams were built on the Seine, but experience soon showed that the difficulties of theory did not occur in practice, and now there are no stronger advocates of these dams than those who boat on the river. The reaction is so great that boatmen absolutely object to having the dam down at all, preferring a slack-water navigation to an open river with a good natural depth.

When dams were first built on the Monongahela there was a similar outcry, and yet these dams have made the coal-trade what it is, and without them it would amount to but a fraction of its present proportions.

I would therefore sum up as follows:

1st. There is no practical method of giving a constant navigable depth on the Ohio except by dams.

2d. Movable dams are better than permanent ones, as they leave the river open when there is naturally a sufficient depth for navigation.

3d. The applicability of movable dams to the improvement of the Ohio River cannot be determined until one is tried on this river.

4th. If it proves a failure the river can be restored to its natural condition at an insignificant cost, and this contest of rival interests will be definitely ended.

5th. In view of the magnitude of the interests to be benefited, it is of great public utility to build and test one movable dam on the Ohio.

WM. E. MERRILL,
Major Engineers, Bvt. Colonel.

I fully concur in the foregoing remarks and conclusions of Major Merrill.

G. WEITZEL,
Major of Engineers and Bvt. Maj. Gen., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

A.

Average stages in the Ohio River at Pittsburg, Pa., as determined by 22 years' gauge observations.

	Below 3 feet.	Between 3 and 6 feet.	Above 6 feet.
	Days.	*Days.*	*Days.*
January	2.4	10.4	18.2
February	0.9	10.6	16.5
March	0.1	5.4	25.5
April	0.1	4.3	25.6
May	1.0	13.0	17.0
June	6.7	15.3	8.0
July	12.8	13.2	5.0
August	14.5	12.5	4.0
September	17.0	8.0	5.0
October	15.4	11.1	4.5
November	7.4	13.1	9.5
December	2.1	11.8	17.1
Total	80.4	128.7	155.9
Per cent. of whole year	22	35	43

Average stages in the Ohio River at Wheeling, W. Va., as determined by 28 years' gauge observations.

	Below 3 feet.	Between 3 and 6 feet.	Above 6 feet.
	Days.	*Days.*	*Days.*
January	0.0	2.4	28.6
February	0.0	3.4	24.6
March	0.0	2.5	28.5
April	0.0	2.3	27.7
May	0.3	4.8	25.9
June	2.3	15.0	12.7
July	6.8	15.5	8.7
August	9.9	15.7	5.4
September	12.9	10.3	6.8
October	11.5	11.9	7.6
November	2.8	7.3	19.9
December	0.1	6.1	24.8
Total	46.6	97.2	221.2
Per cent. of whole year	13	27	60

B.

LETTER OF INSTRUCTIONS.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., February 14, 1877.

SIR: Owing to an impression which continues to be manifested that the improvement of the navigation of the Ohio River by locks and dams, with adjustable chutes, is not admissible when applied to the peculiar navigation of that river, the board of engineer officers constituted by Special Orders No. 15, Headquarters Corps of Engineers, dated February 14, 1877, is convened with the view of taking into consideration and replying to the arguments in opposition to that plan embraced in a memorial addressed to Congress, December 23, 1875, by the Coal Exchange and the Steamboatmen's Association of Pittsburg, a copy of which is herewith transmitted for the use of the board.

The board is desired to maturely consider each objection of the memorialists, and submit its views in detail upon them successively as they appear in the memorial in question.

It is suggested, and the Board is so authorized, that observations be caused to be made, when deemed necessary, to supply any information that may be desired in this investigation and not readily at hand.

The expenses of the board will be borne by the appropriation for the improvement of the Ohio River.

By command of Brig. Gen. Humphreys.

Very respectfully, your obedient servant,

JOHN G. PARKE,
Major of Engineers.

Col. Z. B. TOWER,
Corps of Engineers.

MEMORIAL RELATIVE TO THE OHIO RIVER NAVIGATION, FROM THE PITTSBURGH COAL EXCHANGE AND THE STEAMBOATMEN'S ASSOCIATION.

PITTSBURGH, *January* 17, 1876.

COMMANDING LOCALITY AND INCREASING USEFULNESS OF THE OHIO.

The treatment of the Ohio River in such a way that the greatest benefits may be derived from its navigation is a subject of great importance, not only to the citizens upon its borders, but to the whole country. Its direction, central situation, and fluvial connections, seem to indicate that by a judicious regimen it may be made an essential part in a great eastern and western transcontinental line of cheap transportation, as well as the most useful adjunct of that wonderful thoroughfare, the Mississippi, whose waters form a natural medium of ready intercourse nearly across and connecting the zones of the northern hemisphere.

CONCLUSIONS OF PRACTICAL EXPERIENCE ON THE RIVER.

Your memorialists, with the keen observation inspired by deep personal interest, through a series of many years, have investigated all the various schemes for the river improvement that have been suggested by the best authorities in engineering: they have noted experience elsewhere; and they have carefully drawn the fairest conclusions from these sources, as well as from practical observations growing out of their own business as transporters. The results reached by this guarded process are fully set forth in the annexed report on the Ohio River navigation, prepared with great care and solicitude by a special committee, consisting of citizens long and largely interested in business upon the navigation. This report the undersigned respectfully present, and ask that it may be taken as a part of this their memorial.

WATER CHEAPER THAN RAILROAD TRANSPORTATION.

All the maxims of sound political economy cherish the river interests and are opposed to any adverse system or policy. The recent experiences and demonstrations upon these subjects, the ascertaining of the full value and mission of railroads, and the incontestable proofs that have been given that carriage on navigable waters, when unobstructed and not interfered with by unwise meddling, is and must ever remain far cheaper than by rail, remove all doubt as to its being the duty of the Government to shield from encroachment all the existing water-lines of traffic; to remove obstructions that have been unguardedly placed in them; to improve them on a discreet plan, certain to assist their usefulness, so as, in the aggregate, to cheapen and facilitate intercourse throughout the various sections of the continent.

COMMERCIAL EXCHANGES—LOW CHARGES OF THE UTMOST CONSEQUENCE.

To improve the communications between the producer and the consumer, in order that the carrier from one to the other shall levy for his work the least possible portion of the value he transports, is one of the most momentous of the desiderata of modern times.

In the accomplishment of this on a navigation like that of the Ohio River everything that causes obstructions, delays, losses, should be sedulously avoided, as they increase the transit charges and raise the price of those indispensable necessaries of life whose cost is principally made up of transportation. For, by any means whatsoever, to interfere with or obstruct these commercial highways, so as to prevent cheap transportation of the means of comfort and the elements of prosperity, whether consisting of coal or iron-ore, or breadstuffs and provisions, or the fabrics of our shops and manufactories, is contrary to individual and public welfare. As a general principle, to cheapness should be added safety in the Government dealing, and by these means will be secured the twofold object sought for—cheapness and safety—and the accomplishment of all that can be done to assist this, one of the most munificent of nature's highways.

FRENCH SYSTEM OF IMPROVEMENT NOT ADAPTED TO THE OHIO.

Of all the plans for improving the Ohio, no one has been entertained with as much approbation, in any quarter, as that by locks and dams, with adjustable chutes, now in use on some of the rivers of France. This has been recommended by Colonel Merrill, United States engineer in charge of the Ohio River improvement, and has the weight of his opinion, and that of some others equally eminent in the profession, in its favor. Your memorialists have not been able, after the most diligent research, to take the same view, nor to regard it as admissible when applied to the peculiar navigation and constituents of freight upon the Ohio. Their reasons for its rejection are contained in the annexed report.

EXPERIMENTAL DAM NOT NECESSARY.

An experimental dam to test its merits is recommended to be placed in the Ohio, sufficiently near Pittsburgh to increase the natural height of the water in the harbor six feet. Their objections to this structure are also in the report. Though such an increase in the water-level receives considerable support from the citizens here, your memorialists know of none who are interested in the navigation who are not decidedly opposed to the dam. Were it even a local benefit, if it interfere with a general interest, economical wisdom would forbid its construction.

EXPERIENCE IN FRANCE INAPPLICABLE.

But experience in France, where the streams are comparatively so diminutive and the character of the commodities transported so different, render such precedents of more than doubtful authority. It is well to call to mind that the whole empire of France, before Alsace and Lorraine were detached, contained an area of but two hundred and four thousand square miles, and that the Ohio drains an area of two hundred and fourteen thousand, bound up with the mighty Father of Waters with an addition of more than a million and a half.

FRENCH DAMS TO BE ERECTED IN THE KANAWHA.

But if experimental dams are required to settle the question whether the French plan of improvi g the Ohio shall be adopted, we learn from Colonel Merrill that Chanoine dams are soon to be constructed on the Kanawha. These will afford the required test of the adaptability of the French system, without incurring the charge and risking the apprehended consequences of the proposed experimental structure near Pittsburgh.

TRUE IMPROVEMENT, WITHOUT RISK, RECOMMENDED.

For the improvement of the navigation most certain to be advantageous, and positively not injurious by any possible consequences, a simple plan is sketched in the accompanying report, of minimum cost, and benefiting every class of transporters, from those who reduce the expense of carriage below all others by barge-fleets to the navigators in single freight and passenger steamers. Your memorialists refer to this, confident that its title to support will arrest the attention of unprejudiced inquirers.

BRIDGES THAT INTERFERE WITH THE NAVIGATION.

The injurious effects of the bridges spanning the Ohio, in consequence of their narrow water-ways, are also exhibited in a proper light, and demand the attention of the high authorities in whose hands the remedy for grievances is placed. This whole subject is discussed without favor or passion, the requirements of the navigation are fairly stated, and the protection necessary to the prosperity of the river-commerce distinctly urged. Among the serious obstacles in the way of the navigation created by the defective construction of bridges, there are two that are especially injurious, demanding the immediate interposition of Congress. These are the railroad-bridge at Steubenville, and the wire bridge across the Monongahela in the Pittsburgh harbor. Particular attention is called to both, which have too long been permitted to obstruct the commerce of the Ohio and inflict annual losses upon those engaged in carrying it on.

RELIEF JUSTLY DUE TO CERTAIN CITIZENS.

Add to these several matters the justice and propriety of re-imbursing the respective sums advanced by the transporters of Pittsburgh in 1869 to prevent the construction of the Parkersburg bridge on a plan that would have effectually stopped the naviga-

tion of the river at that point, and your memorialists commit the several subjects embraced herein to the wisdom and discretion of your honorable body, trusting that the great transportation-interest in question will not be tampered with by mistaken legislation, or suffered to decline by indifference. Its inherent importance to all sections and to all classes having become universally apparent, it cannot but receive the guarding care due to it from the Government. Your memorialists, therefore, respectfully, but earnestly, pray for that remedial legislation which the nature of the requests and grievances herein set forth entitle them to ask of a just and fair-dealing Government. And they will ever pray, &c.

JOSEPH WALTON,
President Pittsburgh Coal Exchange.
N. J. BIGLEY,
President Pittsburgh Steamboatmen's Association.

To the honorable the SENATE AND HOUSE OF REPRESENTATIVES OF THE UNITED STATES, IN CONGRESS ASSEMBLED.

REPORT ON THE OHIO RIVER NAVIGATION BY THE COMMITTEE APPOINTED ON THAT SUBJECT AT THE JOINT MEETING OF THE COAL EXCHANGE AND THE STEAMBOATMEN'S ASSOCIATION, HELD FRIDAY, DECEMBER 10, 1875.

PITTSBURGH, *December* 23, 1875.

The central situation of the Ohio Valley, its great extent, unequaled productiveness, agricultural and mineral, with its noble system of navigable rivers, have occasioned its rapid settlement and marvelous social and material progress. Its increase in wealth and population is without a parallel. Great cities, large manufactories, comfortable houses, and an annual commerce of many hundred millions, attest a prevailing prosperity scarcely to be found elsewhere.

It is not a century since this broad area, now occupied by millions of inhabitants blessed with all the elements of thrift, was clothed with the primitive forest, whose solitudes were only disturbed by the wandering savage. The lines which marked the course of civilized men in taking possession and occupying this fair part of creation were drawn by the navigable streams, which in their natural state offered to all men the essential benefits of free personal transit, untaxed commerce, and easy exchanges of commodities. It is by the same influence that most of the large towns, not only in this valley, but elsewhere, are situated upon the margin of navigable waters, where they may possess the invaluable advantages of cheap transportation.

INTRODUCTION OF RAILROADS.

Since the introduction of railroads, which dates back but a few years, the question has been raised whether they were not destined to entirely supersede internal navigation. This has been determined by experience, which has proven beyond controversy that transportation by water is, and in the nature of things is destined to continue, cheaper than by any other conceivable means where not obstructed by locks, dams, bridges, or any other artificial structures impeding the navigation and increasing the cost of transportation. A single example puts this in an unquestionable light.

TOW-BOAT AND BARGE SYSTEM OF TRANSPORTATION.

By the tow-boat and barge system, of such recent origin, which has matured to its present gigantic dimensions under the fostering hands of the Ohio River transporters, coal is carried from Pittsburgh to New Orleans, two thousand miles, for eighty cents per ton; less than half of one mill per mile, and less than one-twentieth the railroads' charges for the same service. By the same system a reduction has been made from seventy-five cents to twenty-five cents per hundred on ordinary freight between Pittsburgh and Saint Louis and New Orleans.

THE SPHERE OF THE RAILROADS.

Railroads, nevertheless, have a wide sphere of usefulness. Their trains move with celerity, they save time in the transit of persons and property, and hence they carry the more precious freights and monopolize personal travel. Their excellence in these departments of business has so diminished the demand for single passenger and freight steamers, that but few, indeed, of that description of boats now appear in our harbor, where formerly the shores were lined with them.

CHEAP TRANSPORTATION—ITS IMPORTANCE.

It is thus that the natural operations of commerce, the general demands of trade and intercourse, and improvements in the methods of transportation have settled the question as to the best means of deriving the greatest benefits from the generous river that has contributed so materially to the settlement and growth, not only of the Ohio basin, but of the entire vast valley of the Mississippi. The lowest-priced intercourse and the cheapest circulation of commodities constitute one of the all-important economical achievements sought to be accomplished in the present day. The attention of the whole civilized world is drawn to the subject, and our own wisest practical statesmen are giving it their earnest consideration.

COMBINING TONNAGE IN FLEETS.

In our river system of combining large fleets, moved and guided by single steamers, an unexampled advance has been made in this direction. and the successful demonstrations presented by them have proven conclusively that this system of transportation is the cheapest, and is the true one, far better than any other, to utilize the Ohio navigation.

CHEAPEST TRANSPORTATION IN THE WORLD.

Having thus by a gradual progress from single steamers and unwieldy floating arks, whose freights were always necessarily high-priced, reached, through diligent perseverance and large expenditures, the present perfected system by which the cheapest transportation in the world is performed, it behooves the transporters to watch its interests and protect it against invasions and encroachments, as well as against tampering experiments, however well meant. The experience of the transporters assures them of the true requirements of the navigation, and of the necessity of holding intact all the advantages they now possess.

GREAT THROUGH-LINES AND WAY-LINES.

As the barge-fleets convoyed by tow-boats must, in the nature of things, constitute the great through-lines upon the navigation, all attempted improvements of the Ohio should be so contrived as to increase their safety and expedite their voyages. This is undoubtedly the true policy in the management of our attempted river improvements, and nothing of a different character should be permitted to be done in behalf of single freight and passenger steamboats, because from railroad competition their occupation in this quarter seems to be nearly gone, their business dwindled to comparative insignificance, and their numbers diminished to a small fraction of their former multitude. This decadency leaves their future no better promise than the way-business between the towns and villages along the river shores, and the navigation of the streams flowing into the Ohio.

NEW PLAN FOR THE RIVER IMPROVEMENT.

Many plans for improving the Ohio navigation have been proposed, but none of sufficient consequence to justify serious notice except the one to consist of a series of locks and dams with adjustable or movable chutes, to which Colonel Merrill, the United States engineer in charge, has called attention and recommended as deserving an experimental dam, with lock and chute, to test its practical operation and ascertain whether it is worthy of adoption. The commissioners appointed on the improvement of the Ohio, by several States bordering the river, have also recommended it to the same extent, and Congress last winter appropriated $100,000 for commencing the structure, to finish which is estimated to cost some $600,000 more. It is intended that it shall be built sufficiently near Pittsburgh to raise the water 6 feet in the harbor, and to hold it at that additional height at all times, but especially in dry seasons when the river is low. This plan would require, according to the calculation of Colonel Merrill, forty-six similar dams and adjuncts, between Pittsburgh and Cincinnati, together with fifty-two to Louisville, and sixty-eight to Cairo to complete the entire Ohio navigation.

THE NEW PLAN CONSIDERED AND REJECTED.

This scheme of so-called improvement, coming from such a respectable quarter and partially adopted by Congress, has naturally attracted much attention and employed the anxious thoughts of all interested in the river-transportation business. The undersigned have canvassed it with studious care, and with an earnest desire to arrive at impartial and just conclusions. After thus examining and weighing the subject, they are constrained, with all due respect and deference to the opinion of Colonel Merrill and the corresponding one of the States' commission, to express their unqualified dissent from the same, and their undoubting belief that this plan, if carried out, would utterly ruin and annihilate the entire towing system now working so benefi-

cently upon the Ohio. They are led to this adverse conclusion by various experiences and observations growing out of their business as transporters. Some of these they respectfully submit.

MONONGAHELA NAVIGATION.

1. There are but 4 locks and dams on the Monongahela which the Ohio transporters have occasion to use; it costs 1 cent a bushel to pass coal through these, including lockage, which constitutes one-third thereof, which sum, be it remembered, is for passing 60 miles only from Brownsville down to this city, while it costs no more to transport coal from Pittsburgh to Louisville, a distance of 600 miles, by the present towing system, notwithstanding the river between the two latter points is already obstructed by bridges, to a very serious extent, increasing the cost of transportation as well as the dangers of navigation. At the same rate it would cost 10½ cents to pass 46 dams to Cincinnati; and to get through these, and the 6 additional proposed dams between Cincinnati and Louisville, making 52 locks in all, the cost would be 12¼ cents per bushel, or $3.37 per ton. It is scarcely necessary to add that the river commerce could not exist under such a heavy imposition.

CHARGES TOO HIGH TO COMPETE WITH RAILROADS.

2. The railroads on the banks of the Monongahela, as far as they extend, carry cheaper than the boats which ply the navigation, owing to the heavy charges of the latter. If these charges are necessary, they are a striking commentary against slack-water improvements; if they are not necessary, they should in strict justice and sound policy be reduced. But we assume them to be correct and as low as can be afforded, on account of the character and consequence of the gentlemen at the head of that imrpovement.

ITS LIABILITY TO ACCIDENTS.

3. It is further worthy of note that scarcely a year passes without one or more of these dams getting out of order so as to hinder the navigation longer or shorter periods. Apply this fact to the entire line to Cairo, to contain sixty-eight locks and dams, with complicated chutes, and how irresistible is the inference adverse to them.

EFFECTS OF THE LOCK AT LOUISVILLE.

4. The lock at Louisville affords another illustrative example. When the tows arrive there they have to await their turn, and it takes from one to two hours to make a single lockage of three boats, containing 2,000 tons of freight, or 60,000 bushels of coal. At a time of high water, usually very brief, when large shipments are made, there may be 50 tow-boats, with 500 barges and boats in tow at a time, crowding on with two or three hundred thousand tons of freight, compelling an average delay to the tows in consequence of this lock of from one to five days. During delays the heavy expenses of the entire fleet are going on, and it is thus that the loss of time occasions a large part of the expense of transportation. With the same conditions as at Louisville now, at 52 different dams between Pittsburgh and that city, the commerce now carried on by tow-boat fleets would be ruinously impeded, if not entirely blockaded.

PURCHASED BY GOVERNMENT AND TOLLS REDUCED.

This lock, let it be remembered, has been purchased by the Government and is worked by its agents. A toll of eight cents a ton on the tonnage of every passing craft, with an additional two cents upon steamers and model barges, is charged to keep the work in repair and pay the current expenses. Five cents a ton was the first charge when the Government took possession, but being found inadequate to meet current expenses and repairs the present rates were established, which cost each tow-boat, with her tow, from $600 to $800 a single passage. Twenty-four men, besides four or five mechanics, are required to manage the lock. Is it probable that the proposed new locks, chutes, and dams can be operated with fewer men or at a less expense? or that an equal charge will not be necessary at each dam? for the whole force will have to be constantly on hand and under pay whether the chutes are up or not. But suppose the necessary charge to be but one-half, or five cents per ton on the tonnage of all passing craft, the passage at this rate through sixty-eight locks would tax the towing system of navigation upon the Ohio out of existence.

MULTIPLICATION OF TOLLS.

A charge of eight cents per ton on the tonnage of descending or returning tows, though collected but one way, through 52 locks, would amount to $4.16 per ton to Louisville, or $3.68 per ton for 46 locks to Cincinnati, making 18 cents per hundred to Cincinnati, or about 20 cents to Louisville—this, too, on all ordinary merchandise and freights, for lockage alone amounts to nearly double the entire freight-charges made

at present, without counting the expense of frequent detentions and delays at the locks.

Put both these expenses together and they would constitute a burden that would sink the whole river-transportation business.

REMARKS ON THE MOVABLE CHUTES.

5. It is urged by some inexpert observers that in high water the chutes will be lowered and the tows will pass without hinderance, thus insuring a cheap and unobstructed navigation. This might occur, more or less, in the downward passage. But most of the difficulties and delays which embarrass the passage at Louisville would have to be encountered by the returning fleets, with or without freight, owing to the short duration of the Ohio floods. But even if the water remained high, the upward-bound tow-boats, with their numerous attachments, could not stem the rushing current through the chutes. This supposed high-water condition, however, would be of rare occurrence to the returning fleets; usually they would find the chutes raised and the locks their only method of passing the dams, and a most tardy one it would be when from five hundred to one thousand boats and barges were on their return voyages, using the lock at every dam.

UNDENIABLE FACTS AND INFERENCES.

It is a fact, proven over and over again by experience, that tow-boats with their barges, coming up the river, find great difficulty in passing the existing bridges erected over the Ohio, by reason of the accelerated current occasioned by the abutments and piers occupying a portion of the water-room belonging to the normal current. How much greater, therefore, must be the difficulty of the passage of the series of proposed adjustable chutes or dams with the river clogged, as it must be, by their buttresses, piers, locks, and wicker-works?

LIABILITY OF LOCKS TO GET OUT OF ORDER.

And, then, there is not the remotest probability that all these locks would be in order at the same time. Indeed, the probabilities are that there would be no single moment when all of them would be ready for use, and when serious detentions would not arrest every passing craft. To substantiate this, we quote from General Weitzel's late annual report upon the improvement of the navigation at the falls of the Ohio River:

"SURPLUS FUND.

"Under this head Captain Mackenzie says the following:

"'Accidents to gates and machinery are liable to occur at any time, and to provide for such a contingency, as well as put the boats, &c., in order and make repairs, a surplus fund of $50,000 is required.'

"I desire to add to this suggestion that it is one of the first importance. If at any time a gate would give way, or the steamer or either of the dredges should give way, the canal would either immediately or in a few days become practically useless, and the whole commerce of the western rivers would be paralyzed. It would be such a terribly serious affair that all chance of it occurring should be guarded against."

Dangers of destructive accidents, which this experienced engineer regards as imminent and ever liable to happen to a single lock, are to be multiplied by sixty-eight, in case the proposed river-improvement were carried through to Cairo, and would require a proportionate surplus fund of over $3,000,000 always on hand for probable emergencies. Let it be borne in mind, too, that this required surplus fund is called for out of the public Treasury and in addition to the tolls.

DANGERS, ACCIDENTS, AND LOSSES OCCASIONED BY BRIDGES, AND CERTAIN TO ATTEND CHANOINE DAMS IN THE OHIO.

6. The running of the existing bridges across the Ohio is very analogous to what the running of the contemplated chutes would be. All these structures have to be passed by daylight owing to the lack of passage-space under them, and notwithstanding the utmost vigilance, a season rarely goes round without disasters by wrecks against the piers of some of them. The railroad-bridge at Cincinnati, though it has a channel-span of 400 feet, has occasioned some heavy losses, whilst all the others have been more or less disastrous to the river-commerce. In the downward passage, (were the dams built,) when it is presumed the chutes would be depressed, the elevated objects to define their

locality would be less conspicuous than those that indicate the situation of the bridge water-ways, and consequently the chutes would be more difficult to run than the bridges, the width of the passage-way being about the same, from the increased velocity of the current by reason of the necessary contraction of the river by the construction of locks, piers, and abutments. From the most accurate observations that have been made, it is ascertained that the losses of loaded craft average two to each tow-boat every year, of an average value of at least $2,000 each, and these are mainly occasioned, directly or indirectly, by bridges, they being all serious obstructions, endangering the navigation and entailing these large losses upon the river business. The bridge at Steubenville is the worst and most damaging, its effects being felt in making up tows by the hurry it necessitates and the struggle required to pass it by daylight. Neither could adjustable chutes be run save by clear daylight, even in high water. Were fifty-two of these erected between this city and Louisville, the descent of the tows would be compulsory daylight voyages exclusively, and these liable to be interrupted by fogs and mists, or by anything else that dims and darkens the atmosphere.

PROPOSED EXPERIMENTAL DAM.

7. The proposed experimental dam, before referred to, has been regarded favorably by many of our citizens, under the impression that the deepened water, by facilitating the removal of ponderous articles from place to place about the harbor, would do away with the more costly land-carriage on wagons, carts, and drays now in vogue. This, however, would be but a secondary result, should the test prove satisfactory. To ascertain whether the test will so prove, is the sole object of the Government. The subject is an important one, and the large interest of the transporters, representing a capital of more than $20,000,000 invested in the transportation business upon the Ohio, has naturally induced the closest scrutiny on their part into all its bearings. A dam to subserve such a purpose, with the attachments of lock and adjustable or movable chute, must, altogether, compose an extensive, complicated structure, difficult to handle, and ever liable to get out of repair. The raising and lowering of the chute, passing boats through the locks, and suddenly drawing off the pool by breakage or for repairs, would necessarily occasion frequent fluctuations of the water-level in the harbor, vary and change the shore-lines, so as to render moorings along the shore unsafe, if not utterly untenable.

If the water were retained during a cold winter, earlier freezing and later thawing in the motionless pool would, to more or less extent, hinder business and consume time at the close and opening of the season; and, further, the formation of thick ice would compose an almost irresistible element of destruction when joined by the massive broken gorges from the Allegheny and precipitated against the dam with the irresistible momentum of a spring freshet. In such an event the sudden clearing out of the ice in the harbor would be likely to sweep away much of the water-craft, and do other serious damage.

OTHER PROBABLE CONSEQUENCES OF SUCH A DAM.

During low-water, at any season, it would be exceedingly difficult to make an adjustible chute sufficiently tight to keep the pool at its proper level. This would be an especial difficulty in dry summers and falls, and when the demand for water for lockage is taken into account, it may be incontrovertibly pronounced utterly impracticable. But admit it to be otherwise, and that the dam, lock, and chute could be made perfectly tight, so as to hold the water in the harbor six feet higher than its natural level, would it not in very dry seasons, when the volume of water from above is insufficient to produce a purifying flow, become a foul, stagnant pool, poisoned by the city drainage and the nauseous discharges from innumerable oil-refineries, diffusing sickly and fatal influences, and generating pestilent insects and noisome odors?

OTHER DANGERS TO BE APPREHENDED FROM IT.

Again, suppose such a dam with its complex accessories were erected, and were, from any cause, to get out of order in any of its parts, when a considerable portion of the immense tonnage of Pittsburgh were quietly moored or riding at anchor in the harbor, some loaded for the downward voyage and some waiting for freight; and then, at such a moment, by an unavoidable necessity, a giving way in some part of the structure, a derangement in the operation of the chute or lock, the water raised by the dam were to be suddenly drawn off. As no time would be left to seek security or to change position, what would inevitably happen? Would not a large portion of this valuable craft—steamers, barges, and boats—be stranded high and dry, resting upon an uneven bottom, and rendered entirely worthless? This is no improbable supposition, for all slack-water dams are liable to frequent mishaps, and to conditions rendering the drainage of their pools necessary. How much more liable to such disastrous mischances must a dam be when a comparatively frail and intricate chute constitutes that part of it where the most resisting strength is required?

OTHER OBJECTIONS TO IT.

Among the other numerous objections to this projected dam is the obstacle it would constitute in the way of returning tows, which do not usually come back until the river has subsided below the running level for heavily-laden boats. Then the chute would be raised and the lock would be the only passage-way left. Taking the Louisville lock as an example of the time necessarily consumed in locking through the river craft, what would be the effect of such a situation upon the returning fleets, consisting of a thousand boats and barges, (not an unlikely event, when it is remembered that the tonnage of Pittsburgh numbers more than three thousand such.) The whole mooring shores to Beaver would scarcely give too much room for them to wait their turns. Then, when would they ever get back, were all the sixty-eight dams erected?

THE DAM REGARDED AS UNWORTHY OF A TEST.

The truth is, that on a careful review of this scheme, we cannot but reject it, nor do we regard its inherent value as presenting a question of sufficient gravity to justify any experimental outlay at all. That it would, if adopted, destroy the tow-boat and barge system of transportation, is quite certain, and as heavy investments have been made in that system, and as it has been proven to be by far the best system for securing to the country the greatest benefits that can be derived from the navigation of the Ohio, the committee are earnest in their recommendation that the proposed experimental dam be not erected.

CAUTION AND NOT RASHNESS THE SAFEST.

In this connection the committee cannot forbear characterizing the entrance upon a new project of river-improvement, involving an outlay of many millions, on irrelevant experiences in France, as precipitate and imprudent. There can be no resemblance. There can be no doubt but extreme contrasts between the little placid rivers of France, where these movable dams, on a small scale, are in use, and the Ohio, subject to overwhelming floods, discharging deluges from a surface larger than all France, drifting downward from its headwaters, amid unbroken forests, gigantic trees and woodland wrecks, all surging on its turbid current with fearful swiftness and portentous force. When the massive ice of a cold winter breaks and unites with these they form a terrific combination of devastating elements not to be found in the temperate clime and on the denuded surface of France.

SOME OF THE EVIL CONSEQUENCES IF THE SYSTEM WERE ADOPTED ON THE OHIO.

Before anything can be done toward the construction of these movable chutes, an immense crib, or coffer-dam, 500 feet long, must be erected across the natural channel of the river of sufficient dimensions to inclose all the space needed, and within which the movable dam and its foundations are to be constructed. It is quite apparent that such solid and extensive works, thus placed, would absolutely blockade the river a great portion of the time, and inevitably occasion fatal accidents when its navigation was practicable. It will be necessary, we learn from the engineer, for these blockading cribs to remain in the way at least two years; the time estimated as needed for the work to be done in them. Without arrogance or disrespect, it may be asked, what right has the Government, for any purpose whatsoever, to so obstruct and impair a great commercial highway, established by the Creator for the free use of all men? Numerous and heavy would be the losses from such works, and the claimants for damages could press their demands on irrefragable grounds of right and justice.

WHY IT WILL NOT DO BETWEEN LOUISVILLE AND CAIRO.

The engineer in charge admits there is a doubt of the practicability of this system in the Ohio between Louisville and Cairo. This is occasioned by the sedimentary sands abounding there, which are liable to be moved and redeposited during the river freshets, forming new bars and shoals, and making frequent variations of the channel. By these natural changes in the river bottom, established chutes would be ever liable to be closed, or to be too much choked and clogged for use. Without the sixteen dams between Louisville and Cairo, how could the fifty-two between Louisville and Pittsburgh be made useful for the entire river-navigation? Provided this new plan of slackwater were all that is claimed for it, it would, in this case, be fatally cut off and severed from the Mississippi by a fearful gap of near 400 miles.

THE ONLY REALLY USEFUL IMPROVEMENTS.

In conclusion, the committee are of the opinion, from the best lights that have been shed upon the subject, and from all the experience that has been gained in the prac-

tical operation of the tow-boat system since its beginning, that the best method of improving the Ohio River would be to keep it nearly in its unobstructed normal condition; to remove wrecks, snags, and other obstructions; to place wing-dams where the waters spread too much, and at the head of some of the islands, to turn the water and increase its depth on the channel side; to require channel-spans of five hundred feet length in all the bridges crossing the river, and to insist upon the immediate alteration to this length of the water-way under the bridge at Steubenville, pronounced by the United States engineers the worst one and the most serious obstruction to navigation now existing on the river; to recommend caution in the removal of bars at ripples, so as not to injure the navigation by draining down the pools above; to take effectual measures at once to cause the immediate raising of the Monongahela wire-bridge, and putting into it a channel-span of five hundred feet in length and eighty feet in height above low water, so that that structure, which so outrages the rights of transporters, who have submitted too long to its damaging effects, may no longer remain a nuisance and incessant injury to the harbor business and the river commerce

COMPARATIVE COST OF THE TWO PLANS.

All these salutary things may be effected at a very small cost compared with that of the projected sixty-eight dams with locks and adjustable chutes, the lowest estimate of the cost of which is from $40,000,000 to $60,000,000. In this manner, besides doing the best that can be done to facilitate the movements of the great floating tows, the navigation would also be improved for single boats, though it would not be altogether perennial. The two interests, however, would be subserved as far as the incompatibility of their requirements would permit, the most important needing the least expenditure. It would thus appear that, for the least expensive aid, the best would be done that can be to help onward the progress of the latest advancement in the way of cheapening the carriage of ponderous commodities to the places where they are most wanted to promote the prosperity and comfort of the people inhabiting broad sections of our great republic.

THREE MERITORIOUS OBJECTS FOR APPROPRIATIONS.

Before closing, the committee beg leave to suggest that less than one-half of the sum necessary to construct the proposed experimental dam, with its appurtenances, would be adequate to cause the removal of the two most serious obstructions to the river commerce now existing, and to supply the means of performing a signal act of justice to individuals, by returning money advanced by them for the important purpose of warding off a fatal obstacle in the way of the Ohio trade, when about being placed in the river at Parkersburg.

THE STEUBENVILLE BRIDGE.

The first of the two obstructions referred to is the bridge at Steubenville, a most formidable and unintermitting evil, besetting the business of the transporters with its mischievous effects, at its very beginning, in the organization of its fleets, in their descent to it, in their passage through its cramped and inadequate water-way, and in their being thrown out of time by it for the whole voyage, above it and below it, subjecting them to vexations, dangers, delays, and losses. These objections, all serious and of unjust continuance, cry aloud for speedy removal. The widening of the water-way under this bridge to 500 feet, so as to meet the requirements of the navigation, would save an annual cost in embarrassments, delays, and wrecks occasioned by it, of not less than $200,000 a year, which would enure to the benefit of both consumers and producers.

THE HARBOR WIRE-BRIDGE

Crossing from Pittsburgh to Birmingham, is the second obstruction calling for immediate displacement and correction. The leading objections to this structure have been before referred to; they are of great magnitude, and cannot be permitted longer to exist without the grossest disregard of violated rights and ever-recurring injuries, public and private. It stands in the midst of the harbor, where its narrow spans and low superstructure make it a perpetual obstruction to the free passing of water-craft, and in times of high floods so effectually cuts off water-communications above and below that not even the smallest boats can pass. Not a word can be said against the great necessity of relief growing out of this intolerable nuisance. These are both well-known evils, inflicting serious injuries, periodically, upon the large ascending and descending commerce of the Ohio; they are inexcusable nuisances, working hurt, inconvenience, and damage, whose peremptory abatement is one of the first duties of our constituted authorities.

THE PARKERSBURG BRIDGE CASE.

The case before alluded to, of money paid for the public good by individuals, is the last of the fitting subjects above named for Government appropriations. It occurred

in this wise: In 1869 an advance was made to the Baltimore and Ohio Railroad Company, by the transporters of Pittsburgh, to secure a change in the Parkersburg bridge, then in process of erection on a plan that would have utterly arrested the tow-boat navigation of the Ohio, and involved the Government in a large expenditure for its correction, as its defective plan was authorized by a bad law. This money, $31,586.67, when Congress was not sitting, and when no other remedy existed, was advanced in good faith, under the best legal advice, by the transporters; and as it prevented the stopping of an immense trade, and saved the Government from the charge of altering the bridge, the cash advance constitutes an indisputable claim for reimbursement, which it is unjust and inexcusably negligent to withhold.

These three meritorious objects can be accomplished by appropriations amounting, altogether, to not more than one-half the sum that it would probably cost to build, at the outlet of our harbor, the proposed experimental dam with its attachments. The committee therefore suggests that the propriety of making these appropriations is a question eminently deserving serious attention.

The committee would lastly recommend to the consideration of the river interests the following resolution passed by the National Board of Steam Navigation, at their late meeting in New York. It presents a subject of importance, requiring the action of our transporters:

THE INDIANA CHUTE.

Mr. Pink Varble, of Louisville, offered a resolution, which was read, as follows:

"*Resolved*, That the executive committee be instructed by this board to use its influence in Congress to secure an appropriation of $30,000 for the purpose of widening the channel at the head of the falls of the Ohio River, better known as the Indiana Chute."

All of which is respectfully submitted.

SIMPSON HORNER,
ADDISON LYSLE,
J. A. BLACKMORE,
J. M. SCHOONMAKER,
J. N. O'NEIL,
GEORGE T. MILLER,
HENRY B. HAYS,
Committee.

LETTER OF THE CHIEF OF ENGINEERS.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., March 31, 1877.

SIR: I have just examined the report of the board upon the questions involved in the project of improvement of the Ohio River by movable dams.

In the discussion of that project by yourself and by the board recently convened, there is one point which it seems to me should be more completely disposed of. It has been presented to me twice, orally, by the agents of the coal companies.

They state that although the value of coal annually transported on the river from Pittsburgh is but $6,000,000, and the value of the whole trade of the river may be what you have stated, yet that the question of the improvement of the navigation of the river should not by any means depend solely on such figures. They present their view by stating substantially that the coal companies employ 107 steamers for their tows and probably 3,000 barges—that is, from 20 to 30 barges for each steamer—while the number of steamboats carrying freight and passengers, and steam tow-boats engaged in other transportation than coal on the river between Pittsburgh and Louisville, is but about the one-tenth part of this. That is, I understand them to say that for every one steamboat or tow carrying other freight than coal that goes down or up the river between the points to be improved, there are 10 coal tows passing.

Now, the reply to this involves in part a statement of the number and tonnage of steamboats and tows of other freight than coal passing over the part of the river to be improved.

It may be that I have not exactly stated the position of these gentlemen, but that is the impression it has left on me, and, at any rate, you will perceive, by what I have stated, the nature of the question involved, and I desire a full presentation of it by you.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brig. Gen. and Chief of Engineers.

Maj. WM. E. MERRILL,
Corps of Engineers, U. S. A.

NOTE.—Copies of the foregoing letter furnished Col. Z. B. Tower and Lieut. Col. H. G. Wright, Corps of Engineers, for such remarks as they desired to make.

LETTER OF LIEUTENANT-COLONEL H. G. WRIGHT, CORPS OF ENGINEERS.

ARMY BUILDING,
New York, April 6, 1877.

GENERAL: I have the honor to acknowledge the receipt of the copy of your letter of the 31st ultimo to Maj. W. E. Merrill in regard to a certain point which you present, connected with the proposed application of the movable dam in the improvement of the Ohio River, and upon which you ask for further information. This letter is referred to me as a member of the Board which lately reported upon the subject, for such remarks as I may desire to make.

This point has reference to the relative number of steamboats, barges, and boats used in the transportation of coal, and the number used for all other purposes on the river, upon which relative number the opponents of the improvement seem to base their claim for determining the character of the improvement to be adopted.

I presume that Major Merrill will be able to give a close approximation to the number and tonnage of the steamers and barges used on the river, (a thing which it is impossible for me to procure here,) but it should be borne in mind that a comparison of this number of boats and tonnage as compared with the number of boats and tonnage employed in coal-transportation will afford no just measure of the relative interests of the two as regards the question of river improvement.

The coal-fleets make comparatively few trips during the year—the downward ones being always on high stages of the river—and only the "barges" are brought back; while the "boats" are sold with their cargoes, to be broken up for the lumber they contain. The other boats, on the contrary, are kept running, so long as the depth of water in the river is sufficient, as regular-line boats, carrying both freight and passengers, or as boats for towing one or more "barges," in which the great bulk of the freight is transported. These "barges" are always brought back (loaded if freights are to be had) for further service. The technical "boat," which is simply a rectangular box, is used in coal-transportation only. It thus appears that one of these barges may carry, in the course of the year, an amount of freight many times exceeding in tonnage that which is carried by a coal-barge of equal size. A coal "boat" carries but a single cargo.

I would further remark that the only point definitely determined upon relative to the "radical" improvement of the Ohio River is the construction of the movable dam, some five miles below Pittsburgh, for which an appropriation has been made; and until it has been constructed and fully tested, it seems to me premature to discuss the question of the general improvement of the river by this means. Should it succeed, as the Board believed it would, the same principle can be applied to other parts of the river, if Congress shall decide to continue the improvement.

The trial of this dam will decide, in the only satisfactory way, the many objections that have been urged against its applicability to rivers like the Ohio; and if no other should be constructed, it will be useful in affording a commodious harbor at Pittsburgh during the low stages of the river, while presenting no serious obstacle to the navigation of the river in its high stages when the wickets will be down.

Very respectfully, your obedient servant,

H. G. WRIGHT,
Lt. Col. of Engineers, Bvt. Maj. Genl.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A.

LETTER OF COLONEL Z. B. TOWER, CORPS OF ENGINEERS.

NEW YORK, *April* 7, 1877.

GENERAL: I have the honor to submit the following remarks in relation to the special point raised by agents of coal companies at Pittsburgh bearing reference to the report of the Engineer Board assembled at Cincinnati, February 20, upon the Ohio River improvement. This point is set forth in your letter of March 31, addressed to Maj. William E. Merrill, a copy of which has been sent to me for such statement in connection therewith as I may desire to make.

The coal-transportation companies, in their memorial drawn up to oppose the improvement of the Ohio River by a system of movable dams, argued solely in their own interests, as *they viewed* them. The Cincinnati Board, of which I was a member, in replying to that memorial, stated approximately the value of the commerce on the Ohio River above Louisville other than that of coal to show what vast interests are connected with navigation on that river outside of Pittsburgh. Without intending to measure the relative influence of these two classes of transportation, the Board desired to say emphatically that the coal-transporting companies are not entitled to determine how the Ohio River should be improved.

It may not be fair to measure different transportation interests on the river by the cash-value of the material moved, neither would the number of barges used in any interest be the just measure of its importance. At any rate, the first essential in this matter is to get at the facts. If we are to use statistics as an argument, they must be clearly set forth.

One might infer from the statements of the coal agents that the companies employed ten times as many steamers and ten times as many barges as are employed in all other commerce on the river above Louisville. If this be true, there are no more than eleven steamers engaged upon the river beside the coal-boats. The question arises, how many of these 107 steamers are employed exclusively on the Ohio between Pittsburgh and Louisville? How many pass above the former city or below

the latter? It would be well, therefore, to obtain, if possible, the number of passages made between Pittsburgh and Louisville, or, what is better, the number of miles run between these cities by all the Pittsburgh coal-steamers and by all loaded barges; also, to ascertain the tonnage and value of these steamboats and barges. The same data in reference to steamers and barges doing all other commerce of the river between the same cities should be ascertained as well as it can be. It is my understanding that the coal steamers and barges are employed but a limited portion of the year, and that, were the river navigable at all times, a much smaller number would do the work now done by the larger. There are quite a large number of coal-boats that make but one trip down the river, never to return. I presume Major Merrill can determine or procure the above data approximately, and show the true ratio of the coal-navigation interests to that of all other commerce measured by the coal agents' standard. I have little doubt that it will appear, under his analysis, more favorable to general commerce than would be naturally inferred from their way of setting it forth.

But in this connection it is not to be forgotten that the river is for the benefit of all those who dwell upon its banks, and not for those alone of any special locality; and further, that the interests of the consumer and producer are quite as important as those of the carrier.

A combination to use a highway in a certain manner for the transportation of one kind of produce, may result in a money value to those making the combination by destroying competition in reference to that material, while the consumer and producer might suffer from such combination. At any rate all other interests would probably suffer if the highway were to be kept in such condition that it could only be used at intervals.

Though I do not intend to express any opinion as to the propriety of the improvement of the Ohio River by locks and movable dams, I am inclined to believe that were it accomplished and in every way an eminent practical success in the working, that all interests would be benefited thereby, not excepting the coal interests.

Very respectfully, your obedient servant,

Z. B. TOWER,
Colonel of Engineers, Bvt. Maj. General.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A.

LETTERS OF MAJOR WILLIAM E. MERRILL, CORPS OF ENGINEERS.

1.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, April 12, 1877.

GENERAL: In reply to your letter of the 31st ultimo, calling for a statement of the relative importance of the coal-towing interest on the Ohio River as compared with the general river commerce, I have the honor to submit the following:

The only official document within my knowledge that throws any light on this matter is the annual report of the board of supervising inspectors of steam-vessels. The latest edition is that of 1876, and it is from this edition that I quote. The report is printed at the Government

Printing Office, and a copy can doubtless be obtained for the use of your office by application to the Secretary of the Treasury.

The Revised Statutes of the United States (sections 4417 and 4418) require annual inspections of the hulls and boilers of all steamboats. These inspections are made wherever a boat may happen to be at the end of the year, although, as a general rule, they are made at her home port. Steamboat-inspectors are officers of the Treasury Department, and they report annually to their supervising inspectors, giving the name, tonnage, and the date and place of construction of each boat inspected. By compiling these lists it is therefore practicable to get the name and tonnage of every American steamboat.

On the Mississippi and its tributaries there are the following inspection-districts:

On the Ohio.

Pittsburgh, Cincinnati, Evansville, Wheeling, Louisville.

On the Cumberland.

Nashville.

On the Mississippi.

Galena, Memphis, Saint Louis, New Orleans.

In the inspection-lists steamboats are divided into four classes, viz: passenger, ferry, towing, and freight steamboats. Under the head of towing-steamboats are included those that tow coal, iron, salt, and rafts, and also all harbor jobbing boats, and boats that dredge up gravel for market.

The following table gives a summary of the steamboats that were registered at Ohio River ports during the year 1875:

Ports.	Passenger-boats.	Ferry-boats.	Tow-boats.			Freight-boats.
			Over 100 tons.	Under 100 tons.	Dredges.	
Pittsburg	24	10	94	18	4	1
Wheeling	47	23	19	19	....	1
Cincinnati	57	16	21	3	1	3
Louisville	27	12	7	8	....	5
Evansville	22	6	6	18	....	5
Total	177	67	147	66	5	15

In the above table the tow-boats have been divided into two classes, according as they are over or under 100 tons burden, the object being to show approximately the number of Monongahela or "pool" tow-boats, which, though registered at Pittsburgh, are not Ohio River tow-boats. The table shows them to be about 18 in number. The 94 large tow-boats registered at Pittsburgh are not all coal-towing boats, although I have no data at hand to enable me to distinguish those which are regularly engaged in towing coal from those which are not. On the other hand, many boats regularly engaged in the coal-trade were absent from Pittsburgh when the annual inspection was made, and, therefore, were registered at other ports. No one not thoroughly familiar with the details of the coal-towing trade would be able to select the Ohio River coal-towing boats that belong to Pittsburgh from among the great

number of tow-boats registered at the various western ports of inspection. I believe, however, that the figures presented by the friends of the coal-trade (107 coal-tow-boats belonging to Pittsburgh alone) are correct; but I think that in this 107, the 18 (more or less) "pool" tow-boats that properly belong to the Monongahela, and which would never, except in case of some great emergency, pass the Ohio River locks, have been included.

The number of passenger-boats shown in the table I consider a fair statement of the Ohio River commerce, except as to the port of Pittsburgh. Five of those registered at this port are regular Monongahela packets, and of 9 others just built the majority were probably designed to ply on distant rivers. On the other hand, there are a number of boats running between Cincinnati or Louisville and southern ports that were registered at Memphis, Saint Louis, and New Orleans. The two classes will about balance, and we may, therefore, assume that the Ohio River passenger-trade is fairly presented.

Including the Kanawha coal-tow-boats and those that tow coal from points on the Ohio below Pittsburgh, I think that it would be fair to put the number of Ohio River coal-tow-boats at 150. This being granted, we find that the sum of the passenger-packets (177) and of the freight-steamboats (15) exceeds the sum of the coal-tow-boats by 42.

It is, therefore, evident that the statement made by the agents of the coal companies that "the number of steamboats carrying freight and passengers and steam tow-boats engaged in other transportation than coal between Pittsburgh and Louisville is but about one-tenth part of this," (the coal-trade,) is not substantiated by the actual facts in the case.

As the name, place, date of construction, and tonnage of every steamboat on the western waters is given in the report of the Board of Supervising Inspectors, which is a regular official publication of the United States, I do not see how the conclusions drawn from it can be successfully assailed.

Respectfully, your obedient servant,

WM. E. MERRILL,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

2.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, April 14, 1877.

GENERAL: I have the honor to inclose herewith a slip cut from the Pittsburgh Commercial Gazette of the 13th instant, which is submitted in further reply to your letter of the 31st ultimo, calling for information relative to the commerce of the Ohio River.

Respectfully, your obedient servant,

WM. E. MERRILL,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

INCLOSURE.

We have heard a good deal said of late years about steamboating—that it was, to use a common phrase, about played out, particularly on this end of the Ohio River. It is freely admitted that money is not being made as rapidly and as easily as it was during the war, but we are satisfied that nearly all the boats making Pittsburgh their base of operations have been making a little during the past year or two, notwithstanding the general depression of business. It is also worthy of notice that we have more regular packets now than for several years past, and they are all doing a very fair business. The J. M. Kerr is making three trips per week to Wheeling, the Emma Graham regular weekly trips to Cincinnati, the Exchange ten-day trips to same point. Granite State to Portsmouth, Carrie Brooks to Zanesville, and Salt Valley to Ironton, are making regular weekly trips, and the Express this week entered the Pittsburgh and Parkersburg trade, making two trips per week. Then, we have the John L. Rhoads, Gray's line of three powerful tow-boats and barges, and the Whale and barges in the trade between here and Saint Louis. There are those who believe that four passenger and freight steamers, similar to the Rhoads, would find plenty of business in the Pittsburgh and Saint Louis trade, one to leave here every week. Moreover, it is contended that a line of boats of the right kind could be maintained between here and Cincinnati. As noted in these columns the other day, the owners of the Emma Graham have contracted for a new boat to be completed about the 1st of July. It is also worthy of notice, as an encouraging sign of the times, that more new boats are under contract now, both here and elsewhere, if we mistake not, than for several years past.

3.

UNITED STATES ENGINEER OFFICE,
Cincinnati, Ohio, July 3, 1877.

GENERAL: I have the honor to submit the following additional information concerning the commerce of the Ohio River, which has been obtained in response to your letter of April 14.

It is very difficult to obtain any exact statistics of Ohio River commerce, as it is entirely inland, and therefore not subject to record in custom-houses. The only records that are kept are the voluntary ones of local chambers of commerce, which are compiled solely in order that merchants and shippers may keep posted as to the course of trade.

On the Ohio River, there is one chamber of commerce at Cincinnati, one at Louisville, and, I think, one at Evansville. There is an organization at Pittsburgh, known as the Chamber of Commerce, having for its object the promotion of the general interests of the Pittsburgh merchants. No statistics of river-commerce are, however, preserved by it.

As I understand the object of this investigation to be the procurement of facts that may have a bearing on the construction of the proposed movable dam near Pittsburgh, I have limited myself to that part of the Ohio River extending from Pittsburgh to Cincinnati, and including the latter city.

At Cincinnati I obtained the following statistics from the Report of the Chamber of Commerce for the year ending August 31, 1876:

ARRIVALS DURING THE YEAR (NOT INCLUDING COAL-TOWS.)

Regular packets	2,720
Transient steamboats	38
Tow-boats with tows (other than coal)	21
Total	2,779

DEPARTURES DURING THE YEAR (NOT INCLUDING COAL-TOWS.)

Regular packets	2,747
Other steamboats	37
Tow-boats with tows (other than coal)	24
Total	2,808

Every steamboat (including coal tow-boats) and every "model" barge (these barges do not carry coal) that arrived at Cincinnati during the year is recorded by name and tonnage. The list shows:

Passenger and freight steamboats	128
Tow-boats, (the majority coal tow-boats)	110
Ferry-boats	4
Government boats	2
Dredge-boat (private)	1
	245
Model barges	71
Total	316

The ports of departure and destination of the steamers recorded above are only particularized in the cases of New Orleans, Pittsburgh, and St. Louis. The record shows that during the year, 89 steamboats arrived from Pittsburgh.

The information for the ports above Cincinnati was sought by correspondence, but, after much loss of time and no substantial result, I finally sent my chief clerk, Mr. H. L. Smith, to Wheeling and Pittsburgh to consult with the river editors of the newspapers, the wharf-masters, and others likely to be posted on river commerce, and see if anything reliable could be procured.

The following table was compiled from information furnished by the wharf-masters of Pittsburgh and of Wheeling, and by Mr. Wm. Evans, river editor of the Pittsburgh Dispatch. The information about coal-tows was wholly furnished by the latter.

The table only gives the *departures* from Pittsburgh, but it will be reasonably accurate to assume that the arrivals are equal to the departures. All of these boats and barges pass the site of the proposed movable dam at Davis Island. The information obtained at Wheeling was only used as a check on the accuracy of that obtained at Pittsburgh. There was no important discrepancy between them.

DEPARTURES FROM PITTSBURGH IN 1876.

Freight and passenger steamboats:		
To Wheeling	60	
To Marietta	26	
To Ironton	40	
To Portsmouth	38	
To Cincinnati	62	
To Louisville, and below	42	
		268
Coal-tows:		
To Wheeling	9	
To Parkersburg	1	
To Ironton	20	
To Cincinnati	151	
To Louisville, and below	176	
		357
Miscellaneous tows:		
To Huntington, (oil)	24	
To Mississippi River, (freight)	35	
		59
Total departures		684

Very respectfully, your obedient servant,

WM. E. MERRILL,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A.

T 3.

IMPROVEMENT OF THE MONONGAHELA RIVER.

In my last annual report I stated that an additional appropriation would be necessary to complete the lock and dam at Hoard's Rocks. This appropriation was not made, and therefore I have to report all construction as stopped, and the work under charge of a watchman until such time as a new appropriation will permit its completion.

The present condition of affairs is as follows:

LOCK.

The lock is completed, except the lift and miter walls, which were necessarily omitted until the dam was built, in order that the lock might serve as a waste-weir during construction of the dam, but the foundations of these have been built up to the level of the lower miter-sill. The timber for the lock-gates is all on hand and partly dressed. The iron-work for valves, gates, opening apparatus, &c., is also on hand, and ready to be put in place.

DAM.

The dam is of massive masonry, and its condition is as follows:

A length of 106 linear feet has been completed.
A length of 5 linear feet has been built to the level of 29.50, lacking only 2 feet of being full height.
A length of 82 linear feet has been built to the level of 21.50, lacking 10 feet of being full height.
A length of 52 linear feet has been built to a height of 17.25, lacking 14¼ feet of being full height.
A length of 80 feet has the foundation-course only; and
A length of 75 feet is without masonry.

The total length of the dam is 400 feet. The abutment is 60 feet long and 16 feet wide, and is built up to a height of 2 feet above the crown of the dam.

During the past fiscal year the following work has been done:

	Cubic yards.
Masonry laid	3,349
Rock excavation	240
Earth excavation	700
Stone boated to dam	3,629

Crib-work built above lock, 115 linear feet.

The total amount of masonry yet to be laid in order to complete the work, is 3,266 cubic yards.

The boating of stone ceased September 10; work at quarry and on gates ceased October 15; masonry-work ceased October 18; crib was finished November 30.

The stone for the completion of the work, except a few special stones and some backing-stones, is quarried and on hand at the site of the dam.

The best proof of the solidity of the work is that it stood without the slightest damage the great ice-freshet of last January, which swept away nearly everything afloat in the Monongahela. A careful examination during the low water of the March following, failed to show a single stone moved, or even chipped.

In my last annual report I gave the reasons why this work had cost more than the original estimate, which was in the main due to the increase in excavation for lock caused by the foundations, when uncovered,

proving defective, necessitating a removal from the site first chosen; by the extra cost for engineering and contingencies, due to the dilatoriness of the contractors, and by the necessity of building guard-walls above and below the lock, that were not anticipated in the original estimate.

A careful re-estimate compels me to place the sum needed for completion at $25,000 instead of $20,000, as reported last year. I would strongly urge the appropriation of at least this sum, as our work in its present condition, so far from being a benefit to the navigation of the Monongahela, is a serious hinderance.

It is also important to begin as soon as possible the lock at Laurel Run, 2 miles below the mouth of the Cheat River. When this lock and dam is finished, (which is No. 8 of the series beginning at Pittsburgh,) the Monongahela Navigation Company will put in No. 7, and then there will be a complete slack-water navigation from Pittsburgh to Morgantown, 102 miles.

The lock at Laurel Run, with keeper's house and all accessories, will cost about $115,000, the increase over the Hoard's Rock lock being due to the greater depth and expense of foundations. I would not, however, ask for this sum at one time, and therefore I only request $60,000, which is about as much as can be spent in one year.

ESTIMATE.

For completion of lock and dam at Hoard's Rocks	$25,000
For lock at Laurel Run	60,000
Total	85,000

Money statement.

July 1, 1876, amount available	$37,814 61
July 1, 1877, amount expended during fiscal year	37,295 07
July 1, 1877, amount available	519 54
Amount (estimated) required for completion of existing project	214,000 00
Amount that can be profitably expended in fiscal year ending June 30, 1879	85,000 00

T 4.

IMPROVEMENT OF THE LITTLE KANAWHA RIVER.

The act of Congress approved August 14, 1876, contained the following item:

For the removal of Beaver and Nailor Bend Rocks, and for cleaning out snags and fallen trees in the Little Kanawha, West Virginia, seven thousand three hundred dollars.

This appropriation was made available on the 1st of May, 1877.

With the approval of the Chief of Engineers it was decided to contract for the removal of the two rocks, but to do the rest of the work by hired labor under the supervision of an engineer in the service of the Government.

Bids for removing the rocks are to be opened on the 31st of the present month, (July.) If the contractors comply with the specifications, both rocks will be removed by the 15th of September.

Mr. James E. Bell, assistant engineer, was put in charge of the work

of removing obstructions, with orders to begin at Bulltown and work down stream. He left Cincinnati for the Little Kanawha on the 11th of June.

Up to the close of the fiscal year improvements had been made at Buffalo Shoals and at William Stark's Island. Trees, rocks, and snags had also been removed from the banks and bed of the river at various places.

The following is a summary of the work done to June 30:

Cubic yards of rock removed	220
Cubic yards of gravel and sand removed	450
Number of trees removed	52
Number of snags removed	29
Cords of drift removed	6
Acres of land grubbed	2

In obedience to instructions from the Chief of Engineers, conveyed by indorsement, dated July 2, on letter of Hon. Benjamin Wilson to Secretary of War, requesting that I include in my annual report such statistics as may be obtainable of the commerce of the Little Kanawha, I annex the following letter from Mr. L. B. Dellicker, superintendent of the Little Kanawha Navigation Company, which company has established slack-water from Parkersburg to Spring Creek, a distance of 43 miles, by means of four locks and dams.

OFFICE LITTLE KANAWHA NAVIGATION COMPANY,
Parkersburg, W. Va., July 6, 1877.

DEAR SIR: Yours of the 5th is received. The year ending March 1, 1877, was the first of the successful operation of our works. During that year we passed 388 rafts of logs, containing 696,000 cubic feet, worth at this point about 10 cents per foot, equal to

to	$69,600 00
1,162,900 feet of sawed lumber, at $20 per M	23,258 00
3,406,200 staves for oil-barrels, at $16 per M	54,499 20
57,749 railroad-ties, at 60 cents each	34,649 40
343,000 hoop-poles, at $8 per M	2,744 00
45,050 cubic feet of ship-timber, at 20 cents per foot	9,010 00
Value of timber products	193,760 60

In addition to the above, 12,268 barrels of oil were shipped out, worth at this point about $3 per barrel, $36,804. The rafts, oil-barrels, staves, and oil were principally manufactured at this place. The sawed lumber was shipped to New York, Pittsburgh, Cincinnati, and other points west; the railroad-ties to the Pennsylvania, Cleveland and Pittsburgh, Cincinnati Southern, and other railroads of the West. I have myself seen them in the track of the Camden and Amboy Railroad in New Jersey. The ship-timber was shipped from this place via Baltimore to England.

For the first three months of this year the shipments of the various kinds of lumber are fully double that of the same time reported above. There are not less than 400 log-rafts now in the river and its tributaries awaiting a rise to get to the slack-water. Contracts for over 100,000 feet of ship-timber were made this spring for shipment to England, but owing to the low water the contractors were unable to get the timber to slack-water until too late for shipment this spring.

Yours, &c.,

L. B. DELLICKER,
Supt. L. K. N. Co.

Col. WM. E. MERRILL.

It will be seen from the above that some of the timber grown on the Little Kanawha is exported to Europe, which is also the case with a portion of the petroleum produced.

The further work required on the Little Kanawha is to assist as far as possible the existing rafting and boating interests by continuing the present work of removing obstructions from the main river and the West Fork, and the construction of additional locks and dams for the gradual extension up stream of the existing slack-water.

For the removal of obstructions I would ask for \$5,000. The nature of the work is such that no exact estimate of the amount required for this purpose can be made. Should the sum herein named prove more than is absolutely necessary, the surplus may be applied toward building a lock and dam for the radical improvement of the river.

In my report of January 9, 1875, on the survey of the Little Kanawha River, (Report of Chief of Engineers, 1875, part 1, page 740,) I estimated the cost of a lock 143 feet by 23 feet, with 12½ feet lift, on a rock foundation, at \$40,000. This was a general estimate, and not based on any particular location. I would recommend the appropriation of this sum, as it cannot differ much from the true cost, and no more accurate estimate can be made until a definite location is determined upon and the site minutely examined. I therefore submit the following

ESTIMATE FOR FISCAL YEAR 1878-'79.

For removing obstructions, (any balance unused to go to the lock)	\$5,000 00
For one lock	40,000 00
Total amount required	45,000 00

Money Statement.

Amount appropriated by act approved August 14, 1876	\$7,300 00
July 1, 1877, outstanding liabilities	550 00
July 1, 1877, amount available	6,750 00
Amount (estimated) required for completion of existing project	
Amount that can be profitably expended in fiscal year ending June 30, 1879.	45,000 00

APPENDIX U.

ANNUAL REPORT OF MAJOR JARED A. SMITH, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1877.

UNITED STATES ENGINEER OFFICE,
Indianapolis, Ind., July 12, 1877.

GENERAL: Herewith I transmit my report of operations for improving Wabash River, Ind., for the fiscal year ending June 30, 1877.

Very respectfully, your obedient servant,

JARED A. SMITH,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers U. S. A.

IMPROVING WABASH RIVER, INDIANA.

This work was in charge of Maj. William E. Merrill, Corps of Engineers, until Jan. 22, 1877; on and after that date in charge of Maj. Jared A. Smith, Corps of Engineers. Mr. Fr. Stein has been employed as an assistant engineer through the year.

On the 1st of July, 1876, the following contracts were outstanding:

No.	Work.	Contractors.
1	Dam across cut-off at New Harmony	J. M. & R. B. Kerr.
2	Rock-excavation at Warwick's Ripple	M. W. Nolan.

DAM ACROSS NEW HARMONY CUT-OFF.

During the entire summer and autumn months the water continued at an unusually high stage. In the month of July, when low-water is usually expected, a height of more than 14 feet was reached. The lowest point attained during the entire year was about 1½ feet above usual low-water, and that was for a few days only.

The contractors were much embarrassed by constantly losing portions of their work, and the washing of banks was every day rendering the construction more difficult.

The months of July and August were consumed in repairing injuries, and in September and October the cribs were extended across the cut-off.

On the 1st and 2d of November a flood occurred, which swept away a portion of the completed crib-work, and so much discouraged the contractors that they refused to proceed further with the work, unless reimbursed for losses past, and secured from damages by floods in future. On this account, and owing to imperative necessity for completing the work before further destruction could follow, the contract of Messrs.

J. M. & R. B. Kerr was formally annulled, and the work was carried forward by hired labor. Although unusual difficulties had been met, it is believed that had the work been pushed forward with energy by the contractors, properly securing their work as they progressed, it might have been completed during the proper working-season, and thus afforded an opportunity for the embankment of earth, shale, and stone, which rested against the cribs on the up-stream side, to settle into a compact mass before being subjected to the trials of high water and ice which occurred in the winter.

During the month of November the water remained so high that the crib-work carried away could not be replaced; but in December it was again completed, and the ballasting, embankments, grading, and paving of banks were pushed forward as rapidly as possible, and the work was completed January 17, 1877.

The work, as completed, consisted of a line of cribs 12 to 15 feet wide, according to depth, the top being 12.7 feet above the lowest parts of the bottom, and 6 feet above low water. Against the upper side was an embankment of earth and stony material as high as the cribs, with a width on top of 10 feet, and a natural slope toward the water.

One end of the dam rested against a bluff on a ledge of rock. The other end abutted the island bank of a sandy loam, which seemed to melt like a soluble material in contact with water. The bank of the island, both above and below the dam, a total distance of 350 feet, was graded to a slope of 1 on 2, and carefully paved above water, the part below water being protected by a heavy riprap of stone thrown in, and of course assuming a natural slope.

About a week after the dam was finished a considerable rise occurred in the river, which overflowed the dam and caused some trifling injuries, which were at once repaired.

Early in February the river again rose, and this time overflowed the new dam to a depth of nearly 5 feet, carrying over heavy ice and snags. In a short time a break occurred in the island bank which could not be checked, and it resulted in a channel nearly 200 feet in width around the end of the dam. This unfortunate result necessarily changed much of the subsequent work of improvement.

The channel which this dam is designed to improve comprises a very large part of the difficult low-water navigation between Mount Carmel and the river's mouth.

During the short period in which the cut-off was effectually closed, the increased volume of water in the main channel had done excellent service in removing the bars, and pilots reported a depth of 18 to 20 inches greater than before.

In order to avoid, if possible, a similar accident in future, a study of the break was made, and in accordance with request of the Chief of Engineers a report explaining the causes was submitted under date of April 4, from which the following is an extract:

* * The work was begun by contractors in September, 1875, and was continued through November, when the high water prevented further work until September 1876; meantime one or two breaks had occurred in the parts which had been done, and as a consequence the island bank had been badly washed.

In November, 1876, owing to the many difficulties attending the work, the contractors refused to proceed, and their contract was annulled. It was deemed necessary to complete the work in order to save what had been done, and it was therefore pushed forward by day's labor. The stage of water and other causes delayed the work, so that it was not completed until January 17, 1877, a considerable portion having been done in severest winter weather, and frozen earth, as a consequence, entered largely into the embankment. The banks of the stream were also deeply frozen, as was the water of the stream itself.

As a protection to the island bank, it was paved for some distance above and below the dam, but below the water-level only a loose riprap could be placed.

* * It will be observed that the dam was constructed *against* and not *into* the bank; and in this lay, perhaps, its greatest defect.

A rise in the river to 1 foot above the level of the dam occurred immediately after the work was completed, and caused some slight damages which were repaired as soon as a foothold could be obtained.

A second rise to about 5 feet above the dam followed a few days later, taking the ice from the river, and at the same time the frost was rapidly leaving the earth and making it especially liable to wash. The water and ice falling over the dam on the island slope soon tore away the riprap, and the bank being of extremely loose material, the pavement and end of dam was undermined, letting out the stone of end crib. The washing away of adjacent earth-embankment, the tearing away of the projecting crib-work, and the cutting into the island were the inevitable results. * * *

In making designs for again stopping the flow of water every possible precaution has been taken to insure the stability both of the dam and the island bank.

The appropriation of $70,000, dated August 14, 1876, for the improvement of the Wabash River, having been withheld from expenditure by executive order, the balance available for expenditure previous to May 1, was very small.

As the contract for rock-excavation at Warwick's Ripple was outstanding, and would, if completed according to its terms, consume the entire balance available to pay amounts which would become due the contractors, no definite steps for renewing work at New Harmony Cut-off could be taken.

Early in May notice was received that the Secretary of War had authorized the expenditure of the appropriation of $70,000, and steps were at once taken to proceed with the work.

The land which had been owned next the dam, on the island, by the United States had been entirely washed away. The owner of the island persistently refused to sell any of his lands or material, or in any way permit their use in constructing the dam, unless the work was located at the head of the cut-off, which could not be recommended on account of the largely-increased cost it would entail.

As other points of importance were to be considered, a request was made for a Board of Engineers to decide the points in question. The Board of Engineers met in Indianapolis, June 18, and proceeded to examine the site of the work. After deliberation, it was decided to approve the recommendation from this office, that the flow be stopped by prolonging the remaining part of dam across the break.

The method proposed for securing the banks from injury was also essentially adopted.

A small party was employed in May and June cutting logs and quarrying stone in order that the material may be ready as soon as the river subsides sufficiently to put the work in position.

WARWICK'S RIPPLE.

The contractor for rock-excavation at this place made no serious attempts to carry on the work, owing to the unfavorable stage of water, which would probably have caused considerable loss had he attempted work. For this reason the contract, which would otherwise have expired December 1, 1876, was extended until December 1, 1877.

At this time the water still remains at an unusually high stage, and as no steps are being taken to carry on the work, it seems probable that the contract may fail. The work is not, however, regarded as important, and as no payments have been made, the Government will not be a loser.

LITTLE CHAIN.

This is one of the most difficult points for low-water navigation, as a ledge of rock extends across the river for a considerable distance, at a place where there is a short bend in the river. To make the channel navigable at all stages of water, would be both difficult and expensive.

During the last year, some work was done clearing away trees and snags, with reference to turning the current through the cut-off. The distance through the cut-off is a little shorter than by the main channel, but now requires a very short turn to enter the head of it from the river. In fact, before the recent operations, a considerable point of land had formed above the head of the cut-off, so that the water for a short distance nearly reversed the direction in which it had flowed before entering.

In December, after the dredges Ohio and Oswego, belonging to the Government, had completed their work on the Ohio River for the season, they were sent up to the Wabash River with the intention of opening the head of the cut-off before navigation should be closed by freezing. Before they reached their destination, however, the river began freezing, and they were compelled to find a refuge in the mouth of the Little Wabash River, where they remained until the ice left the river, early in February, 1877. They were then towed to the head of Little Chain cut-off, and the work of dredging was begun.

The river fell steadily during the month, and it was feared that if the dredges were detained too long, they might be kept there until later rises would permit their passing over the reef, and they were therefore returned to the Ohio River about the last of February. A further reason for not continuing the work further at that time was, that the effects of the increased flow through the cut-off might be observed, as it was considered probable that a large portion of the cutting might be done by the water itself when once well started. The dredges were in charge of Mr. E. J. Carpenter, assistant engineer. The steamer Ella Layman was employed to tow the dredges and scows. In order to turn the current as much as possible into the cut-off, the material dredged was dumped on the opposite shore of the river, and a short distance above.

The following is a summary of the work accomplished:

Cubic yards of earth excavated and removed	14,125.5
Logs and snags dug out and removed	226

Of these snags the largest was 45 feet long, and averaging 47 inches in diameter. Its estimated weight was about 16 tons. The others were of various sizes, weighing from ½ ton to 6 tons.

The point at the head of the cut-off was dredged away so that a boat can enter by turning through somewhat less than a right angle.

If dredges can be procured, it is proposed to continue work at the head, and also to remove snags, and dredge a few small bars in the cut-off.

SURVEYS.

No regular surveys were made during the year. Owing to certain points in question regarding boundaries of United States property at Grand Rapids, a re-survey has been made. Examinations for special purposes have been made in New Harmony cut-off and Little Chain cut-off.

In the office, maps have been completed from the field-notes of former surveys.

LOCK AND DAM AT GRAND RAPIDS.

Plans for this work have received considerable attention, and most of the features have been designed. No work has, however, been commenced, and it is not deemed advisable to begin this construction until it can be seen whether the necessary appropriations will be made.

WATER GAUGES.

Daily records of the stage of water have been kept at Vincennes, Mount Carmel, and the Grand Chain.

The work proposed for the ensuing fiscal year consists in stopping the flow through New Harmony cut-off, excavating at Warwick's Ripple, completing dredging and dikes at Grand Chain, turning current and channel through Little Chain cut-off, and such other improvements as may, upon survey, be found necessary to improve the navigation below the Grand Rapids, and the commencement of work on the lock at Grand Rapids is probable. Special surveys are also contemplated.

APPROPRIATIONS.

The appropriation for the last fiscal year was $70,000. This being withheld from expenditure by executive order until the present working season, the amount remains available for expenditure during the ensuing year.

ESTIMATE FOR 1878–1879.

The following estimate has been submitted with the last two annual reports, and is repeated here, viz:

For rebuilding Grand Rapids lock	$130,000
For engineering and contingencies	15,000
	145,000

Money statement.

July 1, 1876, amount available	$34,114 88
Amount appropriated by act approved August 14, 1876	70,000 00
	104,114 88
July 1, 1877, amount expended during fiscal year	18,435 27
July 1, 1877, amount available	85,679 61
Amount that can be profitably expended in fiscal year ending June 30, 1879.	100,000 00

APPENDIX.

The portion of the river now being improved is comprised in the part forming the boundary between the States of Indiana and Illinois.

The collection-district on the east side of the river is the first district of Indiana.

The nearest port of entry is Evansville, Indiana.

The amount of revenue collected at the nearest port of entry during the last fiscal year is—

(No reply has been received to request for information.)

The amount of commerce which will be benefited by improving the Wabash River, is entirely a matter of conjecture.

Below the Grand Rapids, near Mount Carmel, and the mouth of the White River, there is a very large amount of produce and live stock, for which the only convenient outlet is by river navigation.

It has thus far been impracticable to obtain exact statistics on the subject, but it is undoubtedly sufficient to make the improvements contemplated, below the Grand Rapids, of considerable importance.

It is only in very high water that these rapids can be safely passed without the contemplated lock and dam. This reason alone would be sufficient to prevent any general traffic on the river above that point.

The numerous railroads crossing the river, and others essentially parallel to its course, must necessarily compete with navigation for transporting productions, and, as the railroads are available at all seasons of the year, they will carry a large part of the freight.

The Saint Louis and Southeastern Railroad crosses the river near the Grand Chain. The New Albany and Saint Louis Railroad crosses at Mount Carmel; the Ohio and Mississippi Railroad crosses at Vincennes. The latter point is also reached by the Indianapolis and Vincennes Railroad, Evansville and Crawfordsville Railroad, and Cairo and Vincennes Railroad; the two last-named being nearly parallel with the river.

At Terre Haute the river is crossed by two or more railroads, while several others radiate from the same point.

The river is four times crossed between Terre Haute and La Fayette, at which point several roads find a center. Above this point the question of navigation need not be considered.

Some years since a canal extended from Lake Erie, at Toledo, to the Ohio River, at Evansville, following, for most of the distance, the valley of the Wabash River. During a number of years past the canal has been entirely abandoned, below La Fayette, and only serves a very small interest above that point. Its decline is probably due to the increase of railroad facilities.

About thirty years ago a lock and dam were built at the Grand Rapids, and although but few other improvements were made on the river, the tolls formed a source of large dividends to the navigation company. As many as 230 steamboats passed the lock in a single season, and large numbers were engaged in the traffic below the lock.

Although the population and productions rapidly increased, the river commerce constantly declined, until the company owning the improvements, could no longer afford to keep them in repair; and the only thing which gave any value to the stock of the company was the lands they had acquired.

To ascertain, as far as possible, what amount of commerce will be benefited by constructing a lock and dam at the Grand Rapids, a circular-letter was sent to various gentlemen known to be interested in the business of towns near the river. It was ascertained that at present there are only two small boats plying on the river above the Grand Rapids. A variety of opinions were received regarding the prospective commerce which would follow the improvement of the channels, some regarding the day of navigation on the river, to any general extent, as past, while others were equally sanguine that a large amount of navigation would arise to reap benefit from improving the river.

The commerce of the river, above the Grand Rapids, is now too small to be worth considering.

The markets at New Orleans and elsewhere, which formerly attracted the produce of this section, have so changed that most of the freight now goes in other directions and by other channels.

An increased depth of water in the mouth of the Mississippi River

may tend to re-open the markets, but it is doubtful whether the former shipments by the river can ever be fully resumed.

In order to enable the United States to procure the lands necessary for any works of construction in improving rivers within or bordering on this State, the subject was brought to the attention of the State legislature. The following is a copy of an enactment approved March 5, 1877:

AN ACT to give the consent of the State of Indiana to the acquirement by the United States, either by purchase or condemnation, of lands within this State required for the improvement of the Ohio and Wabash rivers, and to cede jurisdiction over the same.

SECTION 1. *Be it enacted by the General Assembly of the State of Indiana,* That the consent of the legislature of the State of Indiana be, and the same is hereby, given to the purchase by the Government of the United States, or under the authority of the same, of any tract, piece, or parcel of land, from any individual or individuals, bodies politic or corporate, on the banks of the Ohio or Wabash rivers within the limits of this State, for the purpose of erecting thereon locks, dams, abutments, lock-keepers' dwellings, or other structures which may be necessary in connection with the improvement of the said rivers; and all deeds, conveyances of title-papers for the same, shall be recorded, as in other cases, upon the land-records of the county in which the lands so conveyed may be; the consent herein and hereby given being in accordance with the seventeenth clause of the eighth section of the first article of the Constitution of the United States, and with the acts of Congress in said cases made and provided.

SEC. 2. *Be it further enacted,* That in case of failure of the United States to agree with the owner or owners of any such lands as the United States may deem necessary for the purposes named in the first section of this act, within this State, it shall be lawful for the United States to apply for the condemnation of such land, not exceeding ten acres in any one place, by petition to any judge of a court of record of this State in or nearest to the county where the land may be situated, either in term time or vacation, notice of the time and place of such application having been first duly given by publication for thirty days prior to the day of such application in some newspaper of general circulation published in the county where the land lies, or if the owner or owners reside in the State of Indiana, by personal service upon the owner or owners of such land, at least twenty days prior to such application, and thereupon it shall be lawful for such judge to appoint three disinterested freeholders of the county, where such land lies, as commissioners, and having been first duly sworn to well and duly appraise the damages due the owner or owners of said land so proposed to be taken, shall report in writing such damages to the said judge, the amount of damages to be paid to the owner or owners of such land, which report, upon confirmation by said judge, shall be held final and binding upon such owner or owners, and upon the amount being paid to the owner or owners of said land, the title of said land shall vest in the United States, and exclusive jurisdiction and right of assessment and taxation is hereby ceded to the United States, over any lands acquired under the provisions of this act, and over the buildings or property thereon.

SEC. 3. *Be it further enacted,* That this act shall not be construed in such manner as to debar or hinder the process of any court or judge of this State from running within the boundaries of the lands so acquired by the United States [or] over any part of such land for any longer time than the said lands shall be used for the purposes aforesaid.

SEC. 4. Whereas an emergency exists for the immediate taking effect of this act, therefore the same shall take effect and be in force on and after its passage.

APPENDIX V.

REPORTS ON TRANSPORTATION-ROUTES TO THE SEA-BOARD.

THIRD DIVISION OF THE CENTRAL TRANSPORTATION-ROUTE.

UNITED STATES ENGINEER OFFICE,
Baltimore, Md., November 10, 1876.

GENERAL: Early in June, 1874, instructions were received from you, from which the following extract is made:

The river and harbor act, approved June 23, 1874, contains an appropriation for surveys and estimates for the improvements recommended by the Senate Committee on Transportation-Routes to the Seaboard upon four routes indicated in the report of said committee, to be expended in such manner as will secure the greatest amount of exact information for each of said routes.

The survey of that portion of the central route designated as "a connection by canal, or a freight-railway, from the Ohio River or Kanahwa River, near Charleston, by the shortest and most practicable route through West Virginia, to tide-water in Virginia," is assigned to you.

A preliminary report was submitted January 13, 1875. Reports on the subject of the proposed freight-railway will be found therewith from Mr. H. D. Whitcomb and Mr. C. P. Manning. No additional information has been since procured as to the freight-railway.

The surveys for the water-line were made in 1874, under the personal supervision of Lieut. Thomas Turtle, Corps of Engineers, and Mr. N. H. Hutton, assistant engineer. No reports from these gentlemen accompanied the report of January 13, 1875, for reasons therein stated. Since that time the preparation of maps, estimates, &c., has been carried on in connection with the current labors of this office. In these labors Lieutenant Maguire, Corps of Engineers, assisted Lieutenant Turtle most zealously until his detail to the staff of General Terry, for service in the Indian country. It is not considered necessary to introduce here the names of all the gentlemen who assisted so efficiently in the surveys and in the office, as they are placed upon the maps.

Quite full reports from Lieutenant Turtle and Mr. Hutton are hereto appended, accompanied by estimates in detail and illustrative maps and other drawings. These relate to the summit division, the Greenbrier division, and the New River division.

A location for the long tunnel at the summit was made by Mr. William R. Hutton in 1870. When this subject was under consideration by the Board of Engineers of 1874, of which Bvt. Maj. Gen. J. G. Barnard, colonel of engineers, was president, he suggested the examination of a tunnel-line from Brush Creek to Howard's Creek, or to the Greenbrier River, for reasons stated by him. Surveys of both these lines were made under Lieutenant Turtle's immediate supervision. His interesting report and maps indicate the details of the surveys and the results.

He discusses quite fully the cross-section, interior arrangement, ventilation, &c., of the tunnel, the methods of towing by animal-power or by steam, the use of a chain or cable in towing, the kind of fuel, the passage of boats singly or in fleets, the elevation of the tunnel above

tide, the advantages of the several locations as to shafting, &c., the debouches, the rate of execution, the arrangements for feeding, &c.

Surveys were also made, under Lieutenant Turtle's supervision, down the Greenbrier River, resulting in locations and estimates for a slack-water navigation or an independent canal.

The survey of the New River division was made under the personal direction of Mr. N. H. Hutton, with a view to a location and estimates for slack-water navigation, as well as for an independent canal. The shortening of the line by cut-off tunnels was also considered.

For the cost of the enlargement of the James River Canal from Richmond to its present terminus, (Buchanan,) and its proposed extension thence to the mouth of Fork Run, according to the location of Mr. Lorraine, reliance is still placed upon the estimates of Mr. W. G. Turpin, an abstract of which will be found in the report on the water-line of January 27, 1871. The detailed estimates of Mr. Turpin are appended hereto.

In the report of January 13, 1875, brief mention was made of the Great Kanawha River as a part of the central water-line. In March, 1875, there was an appropriation by Congress of $300,000 for its improvement, and a second one of $270,000, August 14, 1876. A special report on that improvement, by the superintending engineer, dated April 30, 1875, and a report of a Board of Engineers, dated May 25, 1875, may be found in part 2 of the Annual Report of the Chief of Engineers for 1875, beginning at page 89.

The work contracted for under the appropriations mentioned above, is in pursuance of the plan of improvement recommended by the Board, viz, of large locks, with movable dams, from the mouth of the river to Paint Creek, and permanent dams at and above that point.

A good map of the Kanawha has been in existence for some years, made by Mr. Byers, from his own surveys in 1856. Other examinations have been made of portions of the river, by Ellet, Gill, Lorraine, and others. In 1873 and 1874, special additional surveys were made by Mr. A. M. Scott, whose report is herewith, accompanied by estimates. A special report by Mr. William R. Hutton is also appended.

The following is a summary of the estimates taken from the appended reports:

Mr. Turpin's estimate for enlarging the existing James River Canal as far as Buchanan, its present terminus, and for constructing extension thence to the mouth of Fork Run, according to the location of Mr. Lorraine, is.	$14,781,000
Deduct cost of lock and ship-lock at Richmond	1,300,000
Total from Richmond to east end summit division	13,481,000
Summit division, Lieutenant Turtle's estimate	16,387,000
Anthony's Creek reservoir, Lorraine's estimate	300,000
Total from Richmond to west end of summit division	30,168,000
For the slack-water project, Greenbrier division, Lieutenant Turtle	6,251,000
New River, Mr. Hutton	11,427,000
Removing bowlders in New River, Mr. Harris*	260,000
Kanawha division	4,000,000
Total	52,106,000

*The total estimate of Mr. Harris for removing bowlders from the bed of New River is	$307,385
From this, in order to know the proper sum to be added to Mr. Hutton's slack-water estimate, must be deducted the amount estimated as necessary for clearing the river in places where the line is not located in the open river. This amount is	46,875
Total	260,510

For the independent canal:

From Richmond to west end of summit division, as before	$30,168,000
Greenbrier division, Lieutenant Turtle	4,765,000
New River division, Mr. Hutton	20,650,000
Kanawha division	4,000,000
Total	59,583,000

The estimates are very full, and it may be confidently expected that the cost of the work, if executed, will be less than the estimate, if money be provided as fast as needed for economical progress.*

Should this water-line ever be opened, it would doubtless only be after a careful revision of the whole subject by a board of engineers. It seems superfluous, therefore, to do more now than put on record a few general statements.

The careful surveys and estimates made since the report of the board of engineers, dated March 18, 1874, prove the correctness of the opinion expressed in the following resolution, unanimously agreed to:

Resolved, That, in the opinion of this board, it is entirely practicable to connect the waters of the James and Ohio Rivers by a water-navigation of seven feet depth.

It will be interesting also to recur to another resolution of the same board, which was agreed to by four of its five members:

Resolved, That, in the opinion of this Board, the water-line by the James River and Kanawha route, with seven feet depth, may be completed in six years at a cost of not more than $60,000,000, allowing an unusually broad margin for contingencies which cannot be accurately measured. The cost may be reasonably expected to be within $55,000,000, and possibly will not exceed $50,000,000.

The existence of the Chesapeake and Ohio Railroad has added greatly to the estimated cost of the water-line. The building of another railroad along the New and Greenbrier Rivers would probably make the cost of the water-line so great as to be prohibitory of its construction.

As attention has been directed to the line of the Chesapeake and Ohio Canal, as a proposed substitute for the central water-line by way of the James, Greenbrier, New, and Kanawha Rivers, it seemed proper to compare the two as to their respective features. Accordingly Lieutenant Turtle has, at my request, prepared a comparative statement, which is appended hereto.

Objection having been made by some parties to the proposed improvement of the Ohio River by locks and dams, and the same having nearly as much pertinence to the similar improvements of the Great Kanawha River, a forcible reply thereto (devoid of professional technicalities and therefore suited to the people generally) is appended hereto, which appeared in the columns of the Pittsburgh Commercial.

The original report of McNeill, of 1828, on the water-line, must always be of great interest and value in the study of the subject of which it treats. As it is nearly unobtainable at present, a copy is appended to this report, in the hope that it may thus be put again in print. For the same reason are added copies of special reports on the Great Kanawha, by Mr. John A. Byers, dated February 1 and 10, 1868, and copies of reports in January and October, 1852, by Mr. E. Lorraine, on his survey of the summit-level.

The United States having begun the improvement of the Great Kanawha River by locks and dams, it should not be forgotten that certain rights and privileges have been granted, under the laws of Virginia and West Virginia, to a board or company, relative to the improvement of the

* The details of the estimates are omitted, but are to be found in the records of the Engineer Bureau, with the maps and note-books relating to this subject.

Kanawha, the collection of tolls on navigation, &c. Copies of these laws, &c., as far as known to me, are herewith.

In this connection, the enactment is suggested for application to the Kanawha of a law similar in its provisions to the act of Congress approved March 3, 1875, "to aid in the improvement of the Fox and Wisconsin Rivers in the State of Wisconsin," of which a copy is herewith.

Very much has been written concerning the central water-line. Those who wish to study the subject are advised to consult, in addition to the papers appended hereto, the following, which are in print:

1. Report dated January 27, 1871, and attached papers; (see Ex. Doc. No. 110, House of Representatives, Forty-first Congress, third session;) also, printed in part in Annual Report of Chief of Engineers, 1871, beginning at page 624.
2. Reports, dated December 12, 1872, and April 11, 1873. (See Annual Report of Chief of Engineers, 1873, beginning at page 828.)
3. Report dated March 18, 1874. (See Annual Report of Chief of Engineers, 1874, part 2, beginning at page 86.)
4. Report of the select Committee on Transportation-Routes to the Seaboard, with appendix and evidence, being Senate Report 307, parts 1, 2, and 3, Forty-third Congress, first session.
5. From page 87 to 98, part 2, Annual Report of Chief of Engineers, 1875.
6. Report of January 13, 1875, printed in Senate Ex. Doc. 19, part 2, Forty-third Congress, second session, and in the Annual Report of the Chief of Engineers for 1875, part 2, beginning at page 631.
7. Ellet's report on the Great Kanawha, 1858.
8. Annual Report of the Chief of Engineers for 1876.

Repectfully submitted.

WM. P. CRAIGHILL,
Major of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

COMPARATIVE STATEMENT OF DISTANCES, ETC., RELATIVE TO THE CENTRAL WATER-LINE AND THE CHESAPEAKE AND OHIO CANAL, BY LIEUTENANT THOMAS TURTLE, CORPS OF ENGINEERS.

BALTIMORE, MD., *August* 16, 1876.

MAJOR: According to your request, I submit the following comparative statement of distances, &c., relative to the central water-line and the Chesapeake and Ohio Canal.

The horizontal distances are from the following authorities:

Richmond to City Point.—Coast Survey map.

City Point to Newport News.
Newport News to Capes.
Newport News to Georgetown.
Newport News to Baltimore.
Georgetown to Baltimore.
} State map of Virginia.

Point Pleasant to Richmond.—From the various surveys and reports of the James River and Kanawha Canal; of the central water-line, and reports on the Kanawha.

Pittsburgh to Georgetown.—Reports on Chesapeake and Ohio Canal.

Pittsburgh to Cairo.—Reports on Ohio River.

Cairo to Saint Paul.—Reports on Mississippi River, and report of Senate Committee on Transportation.

Cleveland to Portsmouth.—From report of Senate Committee on Transportation.

TABLE No. 1.—*Showing horizontal distances between certain points via central water-line and via Chesapeake and Ohio Canal.*

Names of points.	New York City.	Capes of Virginia.	Newport News.	Baltimore, Md.	Georgetown, D. C.	Richmond, Va.	Pittsburg, Pa.	Point Pleasant, W. Va.	Portsmouth, Ohio.	Cincinnati, Ohio.	Louisville, Ky.	Cairo, Ill.	Saint Louis, Mo.	Mouth of Illinois River.	Rock Island, Ill.	Prairie du Chien, Wis.	Saint Paul, Minn.	Chicago via Illinois River.	Parkersburg, W. Va.	Marietta, Ohio.	Cleveland via Miami Canal.
New York City	....	293	317	455	467	414.5	1151.5	888.5	978.6	1071.5	1205.5	1569.6	1769.6	1810.6	2141.6	2317.6	2530.6	2129	968.5	977.6	1214.5
							807.5	1070.5	1166.6	1253.6	1385.6	1751.6	1951.6	1992.6	2323.6	2509.6	2654.6	2311	990	981.5	1426.5
Capes of Virginia	....	....	24	162	174	121.5	858.6	595.54	685.6	778.6	910.6	1276.6	1476.6	1517.6	1848.6	2024.6	2237.6	1836.1	675.6	684.6	951.5
							514.5	777.5	867.6	960.6	1092.6	1458.6	1658.6	1699.6	2030.6	2206.6	2419.6	2018	697.5	688.5	1133.5
Newport News	....	....	....	168	180	975	834.5	571.5	661.5	754.5	886	1252	1452	1493	1764	2000	2153	1811.5	651.5	660.5	927.5
							520.5	783.5	873.5	987.5	1118.5	1484.5	1684.5	1725.5	2056.5	2232.5	2445.5	2044	803.5	694.5	1139.5
Baltimore, Md	....	....	....	....	200	265.5	1002.6	739.6	829.6	922.5	1054.5	1420	1620	1661	1992	2168	2381	1979.5	819.6	828.6	1095.5
							540.5	803.5	893.5	1007.5	1138.5	1504.5	1704.5	1745.5	2076.5	2552.5	2465	2064	725.5	714.5	1159.5
Georgetown, D. C.	....	....	....	....	....	277.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
							340.5	603.5	693.5	786.5	918.5	1384.5	1504.5	1545.5	1876.5	2052.5	2265.5	1864	523.5	514.4	959.5
Richmond, Va	....	....	....	....	....	......	737	474	564	657	789	1155	1355	1396	1727	1903	2116	1714.5	554	563	830
Pittsburgh, Pa	....	....	....	....	....	......	......	263	353	467	598	964	1164	1205	1536	1442	1925	1523.5	183	174	619
Point Pleasant, W. Va	....	....	....	....	....	......	......	......	90	183	315	681	881	922	1253	1429	1642	1240.5	80	89	356

NOTE.—Where the distances are not affected by either of the lines, the distance in miles is written in the middle of the square; where the distances are so affected, that pertaining to the central water-line is written in the upper part of the square, while that via Chesapeake and Ohio is written in the lower part of the square. The distances to Georgetown via the central water-line, and to Richmond via the Chesapeake and Ohio, are omitted.

Table No. 2 shows the total lift (ascending and descending) between certain points.

TABLE No. 2.

	Feet.
Pittsburgh to Georgetown via Chesapeake and Ohio Canal, about	3,187
Point Pleasant to Pittsburgh	495
Parkersburg to Pittsburgh	132.6
Marrietta to Pittsburgh	132.2
Point Pleasant to Richmond	2,911
Point Pleasant to Parkersburg	43.5
Point Pleasant to Marietta	55.3

Table No. 3 shows the equated distances between those points affected by the two lines, (Central, and Chesapeake and Ohio.)

The Central is intended, at the outset, to be operated by steam. The experiences of the William Baxter steam canal-boat on the Erie Canal indicate that with steam one minute to each foot of lift is an ample allowance of time in equating distance, and such boats, when freed from the petty and unjustifiable annoyances and hinderances put upon them by horse-boats, will be able to make three miles an hour when fully under way, without injury to the banks.

I estimate that the summit-tunnel of the Central line (single width, with turnouts for fleets) will cause an average delay of 19½ miles—say 20 miles.

Colonel Sedgwick estimates that the use of the proposed planes on the Chesapeake and Ohio will save 52 miles in equated distance. On the basis supplied by the above, the equated distances of Table 3 are compiled. The horizontal distances corrected for lift are increased by 20 miles for the Central line and diminished by 50 miles for the Chesapeake and Ohio, the 2 miles additional saved by the planes being supposed to be lost in the summit-level.

TABLE No. 3.—*Showing equated distances between certain points via central water-line and via Chesapeake and Ohio Canal.*

Names of points.	Pittsburgh, Pa.	Point Pleasant, W. Va.	Portsmouth, Ohio.	Cincinnati, Ohio.	Louisville, Ky.	Cairo, Ill.	Saint Louis, Mo.	Mouth of Illinois River.	Rock Island, Ill.	Prairie du Chien, Wis.	Saint Paul, Minn.	Chicago via Illinois River.	Parkersburg, W. Va.	Marietta, Ohio.	Cleveland via Miami Canal.
New York City	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	1331.5	1044	1134	1227	1359	1725	1925	1966	2297	2473	2686	2284.5	1126.4	1135.8	1400
	916.8	1305.5	1295.5	1388.5	1520.5	1886.5	2086.5	2127.5	2458.5	2634.5	2847.5	2446	1106	1122	1561.5
Capes of Virginia	1038.5	751	841	934	1066	1432	1632	1672	2004	2180	2393	1991.5	833.4	842.8	1107
	623.8	911.5	1001.5	1094.5	1226.5	1592.5	1792.5	1833.5	2164.5	2340.5	2553	2152	813.7	804.4	1267.5
Newport News	1014.5	727	817	910	1042	1408	1608	1649	1980	2156	2369	1967.5	809.4	818.8	1083
	629.8	917.5	1007.5	1100.5	1232.5	1598.5	1798.5	1839.5	2170.5	2346.5	2559.5	2158	819.8	810.4	1273.5
Baltimore, Md	1183.5	895	985	1078	1210	1576	1776	1817	2148	2324	2537	2135	977.4	986.8	1251
	649.8	937.5	1027.5	1120.5	1252.5	1618.5	1818.5	1859.5	2190.5	2366	2579.5	2188	839.8	830.4	1293.5
Georgetown, D. C	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	449.8	737.5	827.5	920.5	1052.5	1418.5	1618.5	1659.5	1990	2166	2379.5	1988	639.8	630.4	1093.5
Richmond, Va	917	629.6	719.6	812.6	944.6	1310.6	1510.6	1551.6	1882.6	2058.6	2271.6	1870	712	721.4	985.6
	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Pittsburgh, Pa	......	287.5	375.5	470.5	602.5	968.5	1168.5	1209.5	1540.5	1716.5	1929.5	1528	190	180.6	643.5
	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Point Pleasant, W. Va	......	......	90	183	315	681	881	922	1253	1429	1642	1240.5	82.4	91.8	356
	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......

From this table the following deductions are drawn: If the capes of Virginia be the objective point, the shortest line for all points west of Point Pleasant will be via central water-line. Difference in favor of central, 160 miles. Same if New York be the objective point. If a port on tide-water (Georgetown for Chesapeake and Ohio or Richmond for central) be the objective, 108 miles is saved by the central for all points west of Point Pleasant. If Baltimore be the objective, 42 miles is saved to all points west of Point Pleasant by the central. If a port on Hampton Roads (say Newport News) be the objective, the distance saved to all points west of Point Pleasant by the central is 190 miles.

On the central water-line it may be advisable to adopt one or two double-track planes (or a hydraulic lift) at the eastern approach to the tunnel, instead of the two flights of locks. (Vertical distance to be overcome, 64 feet.) According to Major Merrill's report, the plane at Georgetown, overcoming a lift of 36 feet, will cost about $100,000. The boats on the central will be much larger than those in present use on the Chesapeake and Ohio Canal. If we suppose two planes at the eastern approach to the summit-tunnel of the central to cost $200,000, the saving in estimated cost would be $126,308.57. A plane or vertical lift might be used at Richmond instead of the flight of locks.

On the Greenbrier division it might be advisable to place one plane below Alderson, changing the location as at present made to the following: Leaving dam No. 11 with canal-bottom at the elevation 1,602, as at present, and keeping this elevation till the head of the flats opposite Alderson is reached, and then by a plane overcome the lift of 52 feet, six locks would be saved. I presume the excavation would be about the same as now estimated by including that for the locks. The six locks, exclusive of excavation, would cost about $144,000.

Colonel Sedgwick estimates the cost of a plane of 64 feet lift at $43,331.75, which Major Merrill doubles, on account of the experience at Georgetown. It may be, then, that the plane of 52 feet lift would cost one-half as much as the locks, and a saving of $72,000 would be made. These locks are single, and will have to be doubled, without doubt, when the trade of the line is developed.

It may be that a plane would be advisable in the line round the Great Bend, but our data are not sufficient to permit a recommendation to be made.

If the higher summit (McNeill's) should be adopted, it might be that several planes would be advisable in overcoming the lift from the tunnel to the mouth of Fork Run, (about 288 feet.) I doubt if the use of planes would be advisable between the western portal of this tunnel and the mouth of Howard's Creek, on account of the quite gradual fall (compared with Fork Run Valley) between these points. The total lift to the first pool on the Greenbrier from McNeill's tunnel is 246 feet. The distance from the western extremity of the approach cut to the mouth of Howard's Creek is about 45,000 feet. This would require that the locks (of 8 feet lift) should be at the distance of about 1,400 feet apart, (average.) It might be found difficult in the location of planes to keep the canal upon the hill-side to gain sufficient height.

The tunnel here proposed by McNeill would be, according to his report, 13,920 feet in length. This is with a depth of cutting of 50 feet. The proposed tunnel on the summit-level of the Chesapeake and Ohio Canal is 19,800 feet in length. By a slight variation from McNeill's location, and increasing the depth of approach cuts to 80 feet, the length of the tunnel could probably be reduced to 12,000 feet or less. While referring to this higher summit, I would call attention to the consideration that the short line might permit us to excavate two parallel tunnels at the outset. Then, as the slowness of movement would not interfere with the carrying capacity of the line, the tunnels might each be made of less section than would be permissible with a single tunnel.

McNeill's summit on the central water-line is 1,916 feet above tide. The proposed summit for the Chesapeake and Ohio Canal is 1,944 feet above tide. The summit of the central water-line is about 2° 10′ south of that of the Chesapeake and Ohio.

The present terminus of the James River and Kanawha Canal is 812 feet above tide. That of the Chesapeake and Ohio is about 624 feet. On the James River and Kanawha Canal, from 1848 to 1868, the number of days in which the canal was closed by ice varied from none to fifty-six, and for the twenty years the average was 15.1 days. The Chesapeake and Ohio Canal closes from 1st to 15th of December; opens about 20th March.

On the central water-line, as now estimated for, the canal-trunk is at no point, except at aqueducts, of less width than 56 feet on the bottom. A portion of the Chesapeake and Ohio is but 45 feet.

The proposed canal-locks on the central water-line are 24 feet wide. Those for the Chesapeake and Ohio are but 20 feet wide. This makes little difference in the estimates for the locks, but it makes considerable difference in the question of water-supply and width of the tunnel, and some difference in the cost of planes and the machinery thereof.

The use of steam on the canal will decrease the detention at locks, and will decrease the superiority of inclined planes and the equated saving of distance due to their use.

Respectfully submitted.

THOMAS TURTLE,
First Lieut. of Engineers.

Maj. WILLIAM P. CRAIGHILL,
Corps of Engineers, U. S. A.

LIST OF MAPS, ETC., ACCOMPANYING REPORTS PERTAINING TO THE SUMMIT AND GREENBRIER DIVISIONS.

BALTIMORE, MD., *July 27*, 1876.

MAJOR: The following is a list of the maps, &c., pertaining to the summit and Greenbrier divisions of the central water-line, and accompanying the reports of the survey of 1874:

SUMMIT DIVISION.

1 map (sheet No. 1) of survey from Dunlap's Creek to the Greenbrier division, scale 1" = 1,000'.
1 map, (sheet No. 2,) scale, 1" = 200', of Brush Creek Valley.
1 map, (sheet No. 3,) scale, 1" = 200', of Howard's Creek Valley.
1 map, (sheet No. 4,) scale, 1" = 200', of feeder-line.
38 sheets of cross-sections of Brush Creek Valley.
42 sheets of cross-sections of Howard's Creek Valley.
3 sheets of cross-sections on opposite hill from the northern line, (ravine on the Greenbrier.)
23 sheets of cross-sections of feeder-line.
1 profile of feeder-dam.
3 transit note-books.
7 note-books of cross-sections.
18 level note-books.

GREENBRIER DIVISION.

3 maps, scale, 1" = 200', of Greenbrier Valley, from the feeder-dam to New River.
1 map, scale, 1" = 600', showing the entire Great Bend.
4 sheets of cross-sections at Bacon's Falls.
1 sheet of cross-sections of bar at Alderson.
37 sheets of profiles of dams and dikes.
30 sheets of cross-sections of lock-sites for slack-water.
6 sheets of profiles of dams for canal-lines.
193 sheets of cross-sections of main canal-line.
1 sheet of cross-sections of line on left bank below Alderson, (station 215 to station 225,) pertaining to canal-line, from dam 18 to pool at Wolf Creek.
37 sheets of cross-sections from west portal of Great Bend tunnel, Chesapeake and Ohio Railroad, to the mouth of the Greenbrier River.
1 sheet of cross-sections of lines on the right bank above Alderson, (approach to pool of dam 16,) pertaining to canal-line on the left bank.
1 sheet of cross-sections above dam 16 on left bank.
63 sheets of cross-sections of left bank below Alderson, (dam 16 to the Great Bend.)
7 transit note-books.
1 note-book of soundings.
1 profile-level book.
1 miscellaneous-level note-book.
5 level note-books, profiles of dams and cross-sections of lock sites.
11 note-books, levels on slack-water and canal-line surveys.
17 level note-books, cross-section of canal-line.

Very respectfully, your obedient servant,

THOMAS TURTLE,
First Lieut. of Engineers.

Maj. WILLIAM P. CRAIGHILL,
Corps of Engineers, U. S. A.

REPORT ON LOCATION OF TUNNEL BY LIEUTENANT THOMAS TURTLE, CORPS OF ENGINEERS.

BALTIMORE, MD., *July* 5, 1876.

MAJOR: I have the honor to submit the following report of that portion of the survey for the "central water-line" which was placed in my charge by your letter of July 9, 1874. My instructions, as contained in this letter, were, in part, as follows:

"You will proceed to the neighborhood of the Lorraine tunnel, on the Allegheny summit of the central water-line, and there undertake such further investigations and surveys as may be required to furnish the information needed, to enable a definite and final location to be made of that important feature of the line, and to put the work promptly under contract should Congress provide the means. While locating the tunnel, as a means of passing a great communication through the mountain, you will bear in mind also its office as the summit-level of a canal, and consider carefully the best means of connecting it with the canal or slack-water at either end, and of maintaining its supply of water by suitable feeding arrangements, assuming that supply to be sufficient."

In accordance with these instructions, parties were formed about the middle of July, and work commenced on the 20th of that month. The transits were in charge of Mr. R. H. Talcott and Mr. S. F. Adams, and the levels were taken by Messrs. J. A. Harris, Henry Fairfax, Thomas Bernard, and Marsden S. Manson. I take pleasure in acknowledging the zeal shown by all these gentlemen throughout the survey, and their faithful performance of whatever duty was required of them. It was understood that the primitive object of the surveys in the vicinity of the summit was to determine the advisability of adopting a tunnel-line from Brush Creek (otherwise Jerry's Run) to Howard's Creek, or to the Greenbrier River direct, as a substitute for the line proposed by Mr. W. R. Hutton, in his report to you after his survey in 1870, printed in the Report of the Chief of Engineers for 1871.

This substitute was suggested, subject to the test of actual survey, by Bvt. Maj. Gen. J. G. Barnard, colonel Corps of Engineers, to the Board of Engineers on the James River and Kanawha Canal, convened by Special Orders No. 17, War Department, Adjutant-General's Office, January 27, 1874. This suggestion was incorporated in the report of the board to the Chief of Engineers, dated March 18, 1874, in words as follows:

"It is also suggested that the tunnel and canal construction may be improved by a radical change of location, taking a point near the railroad-crossing in the ravine of Brush Creek (or Jerry's Run) for the eastern terminus, and the same point on Howard's Creek for the western. By this it is supposed that 2 miles of canalling would be saved, and the location laid in a more open valley (Brush Creek) than Fork Run; or finally, and possibly, by starting from the last-named point and tunneling a distance scarcely exceeding that originally designed by Mr. Lorraine, (9 miles and a fraction,) the valley of the Greenbrier may be reached, by which the expensive canalling in Howard's Creek and the feeder would be wholly dispensed with. The modifications of location are not mentioned as matters of positive recommendation, but as subjects for further survey, with a view of having the best possible location."

The survey began at a point near the junction of Brush and Dunlap's Creeks. A line was run up Dunlap's Creek, to connect with the initial point and bench-mark of Mr. Hutton's survey of 1870. This was necessary, as Mr. Lorraine's line and benches of 1853 had disappeared. The surveys extended up Brush Creek to and above the railroad fill. Cross-sections were taken of the valley, at distances of 100 feet, and extended on either side as far as was judged necessary to enable a canal location to be made. An offset was run from station 11 of the line to Dunlap's Creek, and cross-sections were taken on the offset; which enables us to make a connection with Lorraine's location in the valley of Dunlap's Creek and in the pool of dam No. 8 (station 745) of that location. This completed the examination for the eastern approach and connection.

Station 120 + 15 of the Brush Creek line was taken as the initial point for the trial lines for the tunnel location. The directions were obtained as nearly as possible, for the objects in view, from a copy of Captain McNeil's map and from a plot of the Chesapeake and Ohio Railroad, kindly furnished us from the engineer office of the company.

The line from Brush Creek to Howard's Creek is designated on the map "Southern line of 1874," and that from Brush Creek to the Greenbrier River as the "Northern line of 1874." The surveys of, and pertaining to, the southern line were made by Mr. Talcott, and those for the northern line by Mr. Adams.

All surveyed lines were run with transit instruments. Those depressions, which offered any chances for the location of shafts, were surveyed to the right and left of the main lines, as far as was considered necessary for such locations. The lines of levels were carried along the main lines and *all* surveyed lines. The southern line surveys were continued down Howard's Creek to the Greenbrier River, and cross-sections were taken in the valley of the former down to a point below Caldwell Station of the Chesapeake and Ohio Railroad, (to station 108 of the Howard's Creek line.)

The surveys for the northern line extended to the Greenbrier River and up the river for 7,532 feet. An offset line was run up the valley of the middle fork of Howard's

Creek, and another down Howard's Creek and up a ravine, headin g toward the Greenbrier.

The necessary surveys were also made for feeding arrangements from the Greenbrier River.

The information resulting from these surveys has been compiled, and is shown in a series of four maps accompanying this report. Sheet No. 1, on a scale of one inch to one thousand feet, shows the entire ground surveyed from Dunlap's Creek to Greenbrie River. The contours show the exact elevations where they cross surveyed lines, and are but approximate of these lines, except in Brush Creek and Howard's Creek Valleys and along the line of the feeder, cross-sections having been taken in these localities. Upon this map are also shown Hutton's line and proposed location of 1870, and McNeil's proposed tunnel of 1826.

In addition to the surveys mentioned above, the strike and dip of the rock were noted in many places where it outcropped upon the lines; and an examination was made by Mr. Talcott and Mr. Manson of the cuttings and tunnels of the Chesapeake and Ohio Railroad from Brush Creek to Hart's Run. The strikes and dips of the different strata were noted, and specimens (126 in number) of all the different varieties of the rock were secured.

The location of the tunnel-line for the summit-level is the first matter to be definitely fixed, as the connections at both ends depend upon it.

It is assumed that the elevation of the summit shall be somewhat higher than the level of the Greenbrier at its western end or approach.

I find it advisable to first consider the dimensions and form of the cross-section of the tunnel, and that the determination of this matter involves incidentally the discussion of all matters pertaining to the summit division. The late Board of Engineers were "unanimously of the opinion" (see report of Chief of Engineers 1874, Part 2, page 90) "that a tunnel of the dimensions proposed, (54 feet broad by 34 feet high,) *i. e.*, wide enough for *passing* everywhere, should *not* be attempted, and, on the suggestion of one of its members," united "on the recommendation of a single tunnel with turnouts of dimensions" to be "fully set forth in his individual report, with which hereafter, *if found necessary*, a second tunnel might be combined." The tunnel so suggested was to have a water-way 34 feet wide and 7 feet deep, and would have passing-places 140 feet in length at every fourth of a mile. These passing-places would divide the tunnel into a certain number of compartments, *each of which could be occupied by but one boat at a time*, unless the length of the passing-places be increased to permit more than one boat to enter. In such a tunnel, the canal being worked regularly and to its full capacity, system would require that the boats moving in the same direction should occupy alternate compartments, the remaining compartments being occupied by boats moving in the opposite direction. A direct relation exists between the speed of the boats (taken in connection with the distance between turnouts) and the number of boats which can pass out of the tunnel in a given time.

If we suppose

t = fraction of an hour lost at each turnout,

n = number of turnouts per mile, and

v = fraction of an hour occupied in the passage of 1 mile unobstructed, then will

nt = fraction of an hour lost at turnouts per mile, and

$v+nt$ = fraction of an hour required to move 1 mile, including delays at turnouts.

In the time $(v+nt)$, n boats will have emerged from the tunnel. Representing by N the number of boats leaving per hour, we have $n=\mathrm{N}\,(v+nt)$.

The tunnel will be an enormous obstacle in the line of communication, unless it permits the passage of boats as rapidly as they can be passed through the locks. We will suppose six lockages per hour to be necessary, or $\mathrm{N}=6$, we have $n=4$ (passing-places every fourth of a mile). t must, in advance of experience, be assumed. This time, t, is made up of the time lost in slacking the speed of the boat, in hauling it sidewise into the recess, in allowing the other boat to pass, in hauling out of the recess, and starting it forward to attain its ordinary speed. t can scarcely be assumed at less than five minutes ($\frac{1}{12}$ hour), and may equal $\frac{1}{6}$ hour. We will suppose $t=\frac{1}{12}$ hour. Then, from the formula $(n=\mathrm{N}\,(v+nt)$, we find $v=\frac{1}{3}$; that is, *the velocity of movement must be at least 3 miles per hour to permit six lockages in this time.*

If we double the number of passing-places, we find $v=\frac{2}{3}$, or the velocity of movement should be $1\frac{1}{2}$ miles per hour. Twelve turnouts per mile would require a rate of motion of 1 mile per hour.

An increase in the value of t will necessitate an increase in velocity. If $t=\frac{1}{6}$ hour, no possible velocity can enable 6 boats to pass out per hour, let the number of turnouts be what it may.

This substitution of $\frac{1}{6}$ for t in the formula (N being equal to 6) will give $v=0$; *i. e.*, an infinite velocity will be necessary. This is as it should be, for the time of passing from one turnout to another, plus the time lost at turnout, must not exceed the time of one lockage. In this connection, it will be interesting to investigate the probable attainable rate of movement through a channel-way of this width and depth.

Some years since, M. Bazin made a series of experiments at the Pouilly tunnel of the Burgundy Canal, in France, which throws considerable light on this subject. This tunnel of Pouilly is 10.991 feet in length, with a water-way 20.343 feet in width at the water-surface and 18.6928 feet at the bottom. The depth of water varied during the experiments from 7.546 to 7.71 feet. There was no current. The boats were 16.4045 feet in width. "A dynamometer placed immediately behind the tow-boat received the tow-lines directly, and indicated each instant the force of traction. The velocity was determined by noting to seconds the time of passing bench-marks placed at distances of 100 meters.

The results of these experiments presented numerous variations in their details, since the force of traction, more especially the velocity of movement, was incessantly modified through the influence of various causes—such as variable pressure of the steam in the boiler, the accidental movement of the boats in tow, which, not always following the axis of the tunnel, moved obliquely to it and even touched the sides; the wave motion produced by the convoy, &c. "The experiments were nine in number. The boats, when arranged in tows, were lashed to each other as closely as possible—a precaution useful in diminishing the resistance."

The composition of the tows and the observation made for velocity, force of traction, &c., are given by M. Bazin in two tables, which are here consolidated into one and re-arranged. The French weights and measures are reduced to English units. Some of the items in the original tables are omitted as superfluous for our purpose.

TABLE I.

No. of experiment.	Composition of fleets.	Letter for reference.	Mean velocity, in feet, per second.	Distance passed over, with this mean velocity, in feet.	Mean effort, as shown by dynamometer, in pounds.	Work in foot-pounds per second.
1	Consists of one boat, draught 3'.9	A.	2.365	2624.7	1300.4	3076.2
		B.	3.681	1968.4	3769.6	13875.5
		C.	2.815	2624.7	1807.5	5088.5
2	Consists of one boat, draught 4'.4	D.	2.139	2624.7	1234.5	2640.6
		E.	2.345	3937.0	1300.4	3050.2
3	Consisting of two boats, draught as follows: 4'.2 and 3'.46	F.	2.526	3280.9	1675.4	4232.0
		H.	2.692	2624.7	2050.1	5519.0
		I.	2.638	2624.7	1895.8	5001.2
4	Consisting of two boats, draught as follows: 4' and 4'.4, and one empty boat.	K.	2.302	2952.8	1873.8	4311.4
		L.	2.054	3280.9	1366.7	2807.3
5	Consisting of two loaded boats, draught as follows: 4'.27, 4'.2; one boat lightly loaded, draught 1'.115, and one empty boat.	M.	2.221	1312.3	1454.9	3231.4
		N.	2.319	1312.3	1984.0	4600.9
		O.	2.920	4265.3	2601.2	7595.6
6	Consisting of three rafts, draught as follows: 4'.59, 4'.757, and 4'.59.	P.	2.516	3280.9	2777.6	6988.5
		R.	2.487	3280.9	2909.8	7236.0
		S.	2.712	2624.7	3350.8	9087.3
7	Consisting of three boats, draught as follows: 4'.23, 3'.67, and 4'.29.	T.	2.100	3609.0	3483.0	9529.6
		U.	2.099	2624.7	2094.2	4397.9
8	Consisting of three boats, draught as follows: 4'.49, 4'.1, and 4'.166.	V.	2.040	3280.9	2006.0	4091.3
		W.	2.673	3280.9	4078.2	11158.1
		X.	2.349	3280.9	2934.0	6930.9
9	Consisting of seven boats, draught as follows: 4'.527, 4'.33, 4'.59, 4'.56, 4'.0, 3'.969, 3'.018, and two empty boats.	Y.	2.168	5905.6	4166.4	9032.8

For the present we have to consider only the case of a single boat; that is, the first and second experiments.

To facilitate our comparisons, the following table is compiled from the preceding information:

TABLE II.

Number of experiment.	Letter for reference.	Draught of boat, in feet.	Submerged section of boat, taken equal to draught by width, square feet.	Mean effort of traction, in pounds.	Mean effort per unit of section, in pounds.	Mean velocity, in miles, per hour.	Water-section of tunnel, in square feet.	Ratio of water-section of tunnel to submerged section of boat.	Ratio of mean width of tunnel to width of boat.	Ratio of depth of water to draught of boat.
1	A	3.9	64.04	1,300.4	20.3	1.6125	147.2	2.295	1.190	1.935
	B			3,769.6	58.8	2.5097				
	C			1,807.5	28.25	1.9193				
2	D	4.4	72.12	1,234.5	17.1	1.4584	147.2	2.041	1.190	1.714
	E			1,300.4	18.0	1.5988				

On the central water-line the locks are proposed to be 24 feet in width, and the boats will then be about 23 feet 6 inches wide. If we suppose a draught of 6 feet 4 inches in a tunnel 34 feet in width, the water must be 10 feet deep to make the water section bear the same ratio to the submerged section of the boat as in the first experiment, and nearly 9 feet to make this ratio the same as in the second experiment. We will suppose these conditions to be the same, and that for the same velocity the necessary mean effort of traction per unit of submerged section will be equal in the two cases.

We can now compile the following table of velocities and resistances for a tunnel 34 feet wide, and the boats being 23 feet 6 inches in width, with a draught of 6 feet 4 inches.

TABLE III.

Letter of reference.	Velocity, in miles, per hour, as per Table II.	Necessary mean effort of traction per unit of submerged section.	Area of submerged section, 23.5 by 6⅓.	Total effort necessary to produce given velocity, neglecting fractions.	Ratio of width of water-way to width of boat.	Ratio of depth of water to draught of boat.	Supposed depth of water.
		Pounds.		*Pounds.*			*Feet.*
A	1.6125	20.3	148.83	3.021	1.447	1.579	10
B	2.5097	58.8	148.83	8.751	1.447	1.579	10
C	1.9193	28.25	148.83	4.204	1.447	1.579	10
D	1.4584	17.1	148.83	2.545	1.447	1.474	9
E	1.5988	18	148.83	2.679	1.447	1.474	9

This tunnel is somewhat wider in proportion to the width of the boats than the Pouilly tunnel, and of course has less proportional depth.

It will be observed that the last mean velocity of the second experiment (E) is but little less than the first mean velocity of the first experiment, (A,) and, though the second boat was drawing more water than the first, the mean effort per unit of section was considerably less than for the first boat.

For some reason this second boat moved more easily than the first. We will take the second boat for the standard of comparison. If we suppose the resistances to vary as the squares of the velocities, one mile per hour would require 8.022 pounds traction per unit of section according to D, and 7.03 pounds according to E. Seven pounds per square foot will be a total of 1,041.8 pounds force of traction, the necessary amount to move a boat 1 mile per hour.

It was proposed in this single tunnel, with passing-places, to have a timber tow-path 5 feet 9 inches wide, in case horse-power were used on the canal; this tow-path to be omitted if steam-power were adopted on the canal instead of animal-power.

The Ordnance Manual (page 472) gives 120 pounds as the mean effort exerted by a horse drawing a cart or boat walking, and working 8 hours per day. McAlpine mentions that, according to experiments made in France, a horse can exert 143½ pounds for 6 days. These figures refer to a more rapid motion than 1 mile per hour. Trautwine

gives 250 pounds as the power of traction which a horse can exert traveling 1 mile per hour.

But we have here a timber tow-path. The footing cannot be as good as upon earth, even by placing some of this material on the path, (which would cause it to rot out quickly,) and several horses would be necessary, arranged in single file. These disadvantages would seriously decrease the effective power of the horses.

Our boats have 148.83 square feet of submerged section, loaded to 6 feet 4 inches. One pound per square foot seems to me to be all the effective force we could expect under the circumstances from each horse. Assuming this to be so, at least 7 horses would be required for each boat to move 1 mile per hour. At the turn-outs these 7 horses, with drivers mounted, would have to pass the horses of the boat in the turn-out. This manoeuver on a narrow tow-path must be tedious and difficult. The time allowed at turn-outs ($\frac{1}{12}$ hour) is surely as short as with safety can be assumed.

One mile per hour, we have seen, will render 12 turn-outs per mile necessary. Each being 140 feet long, their aggregate length per mile would be 1,680 feet. Thus nearly one-third the entire length of the tunnel would be excavated to a width sufficient for passing boats everywhere, which, with the expense of finishing off the ends of the recesses and the expense contingent on changing from one section to another in the excavation, would probably make fully one-third the difference of cost between a single tunnel 34 feet wide and the tunnel of 52 feet width, as originally proposed. The uncertainty of action of the 34-foot tunnel would still remain to be considered, together with its disadvantage of not admitting an increase in the trade of the line in excess of 6 boats per hour, (*i. e.*, 3 each way,)

A current through the tunnel from west to east would somewhat change the conditions. The eastward boat would have the benefit of this current, and would reach the turn-outs in time probably to pass into the recess before the arrival of the westward boats. The westward boats would have no delay at turn-outs except in the difficulty of passing horses. Supposing no delay, (as might be the case if a recess were provided for horses beyond the recess for the boat,) the formula would reduce to $n = N\,r$, and with a rate of movement of 1 mile per hour, only six turn-outs would be necessary per mile to provide for six lockages per hour. I estimate that a velocity of more than one-half mile per hour will be necessary through a channel 34 by 9 to supply water for the canal eastward to Covington. The westward boats must stem this current, and to make 1 mile actual progress would require about the effort of traction corresponding to the second part of the second experiment. Assuming 148.83 pounds to be the effective effort of each horse, 18 horses would be necessary; an unmanageable number in such circumstances. Fewer horses will give less speed and render more turn-outs necessary.

It may be said that the westward boats will be more lightly loaded than the eastward ones, (*i. e.*, to less than 6 feet 4 inches,) and therefore will offer less resistance than that above mentioned. Generally this will be so. But a large transfer of iron-ores from east of the Alleghanies to the west is to be expected. A single heavily-loaded or slowly-moving westward boat will modify the time of passage of every eastward boat which it meets while in the tunnel, being one for each turn-out. If we suppose but four turn-outs to the mile, and that heavily-loaded boats shall succeed each other at intervals not greater than ten hours, the whole traffic in the tunnel must conform in time of passage to these heavily-loaded boats. A current of one-half mile per hour must render the checking of the speed of the eastward boat and the hauling of it into the recess a difficult manoeuver in a contracted space such as this 34-foot tunnel. It cannot be done quickly. About 300 pounds traction would be necessary to hold the boat in this channel-way against a current of this velocity; more than the effort which two horses put forth in towing at a walk. Without expanding the subject further—already perhaps too long drawn out—I would state my opinion as decidedly opposed to the tunnel with passing-places for single boats, the boats being moved by animal-power. It should be remarked, however, the original proposition contemplated the use of boats which would offer less resistances to movement, as the locks were assumed but 20 feet in width.

If steam-power be used on the canal, the tow-path is dispensed with, and circumstances change. The eastward current will aid the eastward boats, and they should, without doubt, enter the turn-outs, and probably would be able to complete this manoeuver at least in time to enable the westward boat to proceed without delay. The formula $n = N\,r$ will express the relation existing between the velocity of the westward boats, the number of turn-outs per mile, and the number of boats which can pass out of the tunnel per hour. With 4 turn-outs per mile, the net velocity of the westward boat must be $1\frac{1}{2}$ miles per hour to provide for 6 lockages in that time. The actual velocity against the half-mile current must be 2 miles per hour. With this velocity, the resistance per square foot of submerged section would be 28.1 pounds, according to the first part of the second experiment, (D,) and 26.7 pounds, according to the second part (E) of the same experiment. The first experiment gives $28\frac{1}{4}$ pounds for a velocity of 1.92 miles per hour, water-way being 10 feet deep. We will suppose

28 pounds to be correct. The total resistance for a boat drawing 6 feet 4 inches will then be 4,167.24 pounds. Two miles per hour is 176 feet per minute. The work of moving the boat at this rate will be 734,434 foot-pounds per minute, or 22¼ horse-power (effective force) must be employed.

Lagrené says that the co-efficient of the useful effect of the screw varies between 0.42 and 0.64, taking the work of the pistons of the engines as unity.—(Experiences Dynamometriques, par M. Taurines, 1859.) This is for marine-engines. Labrousse states (Traité de Touage sur Chaine noyée) "that in our canal, (France,) where the dimensions of the lock-chambers compel the use of boats with certain particular conditions of form, any system of * * * screws * * * will not realize more than 25 per cent. of the motive force."

The loss in this tunnel must be still greater. It is therefore more than probable that the velocity necessary, with four turn-outs per mile, cannot be obtained with engines at all economical for the navigation of the open canal.

It may be, though exceedingly doubtful, that the power used on the canal could generate a lower velocity, which, with a permissible number of turn-outs, would provide for six lockages per hour. A number of turn-outs permissible in view of expense is here meant. Without discussing the question, I would state an objection to any system of turn outs, which becomes more grave as their number is increased. If the tunnel were worked systematically and to its full capacity, each compartment, as noticed above, would contain a boat, adjacent compartments being occupied by boats moving in opposite directions. Each boat, when arrived at a vacant turn-out, should withdraw into it and remain till passed by a boat moving the other way. It could then proceed. This alternation is positively necessary, and, as long as the working be full and regular, would operate very well, but if there be a failure in either of these conditions, confusion must necessarily ensue. The tunnel proposed would have thirty or more turn-outs, supposing four per mile. Each of the numerous delays incident to any traffic will have its effect in increasing the confusion within the tunnel. One boat moving irregularly will communicate this irregularity, in a greater or less degree, to sixty boats. In a time of slack trade boats would not present themselves at proper intervals at the portals. Some compartments would then be unoccupied by boats, unless indeed all the boats within the tunnel be compelled to await the arrival of those behind them. Outside certain limits this could not be thought of. The captain of each boat, when arrived at a turn-out, must know whether to withdraw into the recess or to proceed. A mistake would be very difficult of correction. We cannot hope that thirty turn-outs will answer our purpose, and a greater number will increase the difficulties. This objection should of itself prevent the adoption of passing-places for single boats in a tunnel of considerable extent.

A single tunnel wide enough for passing everywhere, or two tunnels of single width, would remove this objection. Though the movement would be more slow than on the open canal, the boats could pass out one end as rapidly as they could possibly enter at the other. The importance of decreasing the first cost impels us to provide for an ordinary trade at least, without the construction of the second tunnel, or a large tunnel, if it can be avoided. The movement of boats in fleets seems to offer the only chance for a solution of the problem.

In the formula $n = N(v + nt)$, we can suppose N to be a number of such fleets, and t, instead of the time lost by a single boat at each turn-out, will be the time lost by the entire fleet, and, if the eastward current be sufficiently rapid to enable an eastward fleet to arrive at and withdraw into a turn-out before the arrival of the westward-bound boats, t becomes zero, and the formula reduces to $n = Nv$ for the westward fleets.

Preparatory to the solution of the problem, the experiences at the tunnels of the St. Quentin Canal, in Belgium, and at the Pouilly tunnel, in France, are of great value. M. Lemoyer contributed a memoir to the Annales des Ponts et Chaussées, 1863, on the towage of boats in the tunnels of the St. Quentin Canal, containing much valuable information. It is here condensed, those portions being omitted which do not immediately concern us in our investigations.

"There are two tunnels (Riqueval and Tronquoy) on this canal, separated by a short distance. The Riqueval tunnel is 18,603 feet in length, and the other is 3,606 feet. The water-way was at first 17.06 feet in width, and 7.546 feet in depth, with a solid banquette on each side 4.6 feet wide, and raised about 2½ feet above the ordinary water-level. From the opening of this line, in 1810, to 1857, boats were towed through these tunnels by men and women, eight or ten being assigned to each boat. The boats formerly drew nearly 5 feet of water, and though all the locks had a minimum width of 17.06 feet, the greater part of the Flemish boats had but a width of 14.44 feet. The privilege of the tunnel was free to all. The slowness of movement was such that the boats generally required twenty hours to traverse the Riqueval tunnel from portal to portal. Transit in the same direction could occur only on each second day.

"The increase of commerce necessitated the adoption of some method of traction which would reduce the delay incident to hauling; and January 20, 1840, ten men were employed for each twenty tons, in order to increase the rate of movement and to

double the utility of the canal by permitting transit each way each day. Competition with railroads made the enlargement of the Flemish locks necessary to admit the wider boats, and the draught of the boats was increased to 5.91 feet, and the depth of the water throughout the line to 6.56 feet. With this increase in the draught of the boats, the difficulties of traction became so great that hauling by men was practically impossible. The time of transit, which before this modification of the boats was seven or eight hours, soon increased to sixteen and eighteen hours. By degrees the men, from exhaustive labor, refused to continue work, and an increase of wages could not prevail on them to remain in a service which was beyond their strength. Foreseeing an immediate abandonment of this means of traction, the management tried various means to assure the towing of boats. A trial of steam-towing had demonstrated that its employment was here inapplicable, with the defective smoke-consumers then in use, on account of the inconveniences arising from the gases generated by combustion and because of the ill-effects of frost within the tunnel, which is excavated through chalk, and is but partially lined with masonry.*

"When the boats were towed by hand, doors were used at the ends of the tunnel to diminish the action of the frost, and the shafts had been hermetically closed. Deprived of this mode of traction, the management had recourse to horse-power. The banquettes were not provided with guard-rails, and the use of animals on such a narrow tow-path was not thought of without providing by some means to prevent accidents. Movable guard-rails were then adopted, which removed all danger. Two large transverse bars were securely lashed with ropes near the bow, by means of which the guard-rails were attached to the boat, and moved with it. A horse on each banquette was tied to the fore part of the guard-rail and the tow-line was attached to the boat.

"A fleet of fifteen boats was first tried, towed by 30 horses. The time of transit exceeded 14 hours. Two other trials not more successful.

"Finally, fearing that this low rate of speed was due to the fact that the horses were unaccustomed to this kind of labor, twenty teams perfectly broken by daily use in the approach cuts were used, and placed in charge of the best drivers.

"The number of superintendents was doubled, yet, notwithstanding all precautions taken, the experiment failed completely, as the convoy required 13 hours to traverse the tunnel.

"It was found that the low rate of speed, by compelling the horses to take short steps, neutralized most of their power, and the result produced was altogether out of proportion to the fatigue endured. More powerful means were necessary.

"Out of a number of methods proposed, but one appeared worthy of trial. It consisted simply of a boat fitted with a platform, raised to clear the banquette, on which horses traveled to turn a capstan. A rope or cable attached to some point ahead, and making two turns round the shaft of the capstan, provided the means of forward movement when the capstan was turned. This device was of great value, as the increase of power permitted the formation of tows of 30 to 40 boats. The time of transit was even now from 10 to 12 hours.

"Improvement in the details produced no acceleration of movement, since the resistance due to the contracted width of the tunnel could not be diminished, and it increased in great proportion to the increase of speed.

"The water-way was next enlarged by the removal of one of the banquettes, giving an increase of 4.6 feet in width. As a further improvement the ropes were dispensed with, and a submerged chain was put in use instead. Eight horses were used to tow large fleets, but this number might be diminished according to circumstances. The chain after three years' use has suffered no deterioration, and none of its links have been broken. The arrangement enables each horse to tow about one thousand gross tons, moving regularly with a velocity of about $\frac{3}{4}$ of a mile per hour. This mode of traction has reduced the cost so materially that the toll is less per ton per mile than on any other portion of the canal, or even on the river navigation connected therewith. The time of transit was reduced to about seven hours for ascending fleets, and to little more than five hours for those descending."*

In 1868 † steam-towage with submerged chain, theretofore considered impossible, was inaugurated.

M. Bazin has given in a note (Annales des Ponts et Chaussées, 1868) very interesting details on the use of steam-towage established at the Pouilly tunnel of the Burgundy Canal, in which note were published the experiments mentioned in a previous part of this report. From this note the following information is extracted:

"The tunnel of the Burgundy Canal, in which a system of steam-towage has just been established, has not the exceptional length of that of the St. Quentin Canal. The trade of this line, paralyzed even to the present time by the condition of the river

* Steam-towing has since been successfully inaugurated.—T. T.

† Letter to Prof. G. L. Andrews, U. S. M. A., from Mr. E. Malezieux, Chief Engineer of the Corps des Ponts et Chaussées, transmitted to General J. G. Barnard, Corps of Engineers, U. S. A.

Yonne, the improvement of which is not yet completed, is still less active; and the tunnel is on the least frequented portion, where the annual carrying trade is only about 120,000 tons. Navigation on this account was none the less subject to serious embarrassments which a more active trade would immediately aggravate. The tunnel is 10,991 feet in length, with an approach cut 2,953 feet long at each end. The approach cuts, like the tunnel, are but wide enough for one boat, being 21.98 feet at the water-surface, and 20.38 feet at the bottom.

"The water-way of the tunnel is 20.38 feet wide at the water-level, and 18.7 feet at the bottom.

"The water in the summit-level is constantly 7.2 feet to 7.87 feet in depth. The length of the portion with single widths, comprising the tunnel and approach cuts, is 3.2 miles.

"The rule in operation before the establishment of a system of towage allowed the boats 6 hours to pass over this distance; the convoys approaching from the side of the Yonne entered at noon and midnight, and those coming from the water-shed of the Saône, at 6 o'clock, morning and evening. The motive power was furnished by men to the number of 4 to 6 to each boat. The tunnel having no tow-path, these men hauled on a chain attached along one of the sides.

"The establishment of a more powerful mode of traction became urgent, especially in view of the probable increase of traffic when the canalization of the Yonne should be completed. A decree of April 28, 1866, authorized the creation, at the expense of the state, of a system of steam-towage, which was placed in operation on February 5, 1867.

"The tow-boat employed at the Pouilly tunnel was constructed according to the system of M. Bouquié. This system, of which the small one in use at Paris, in the last level of the St. Martin Canal, is a specimen, is distinguished from other methods in this, that the chain, instead of passing over the middle of the boat, rests simply on a pulley at the side, passing over only a portion of its circumference. The groove of this pulley is provided with recesses in which the links of the chain are engaged, which requires that the links should be of a uniform size. The lateral position of the pulley has, for very narrow tow-boats, as those operating in a tunnel of single width should be, the advantage of clearing the deck, which the passage of the chain over the middle of the boat would incumber to an extent frequently dangerous and embarrassing while maneuvering.*

"The engine is high-pressure and condensing,† of fifteen horse-power. Motion is transmitted to the shaft of the pulley by means of a belt and gearing under the deck, which thus remains perfectly free. The gearing permits two different velocities of the pulley, according as the boats in tow be heavily or lightly loaded. These velocities are as 3 to 5. The total length of the boat is 72.2 feet, and its width 10 feet 8 inches. It cost $8,074.50.

"The steam tow-boat at the Pouilly tunnel is probably the first employed for this purpose in France, and the experience here obtained furnishes useful data on the special difficulties of its use in like cases. The resistance to traction, on which a connected series of experiments has not been made, is very great, and the movement of convoys creates very complicated undulatory motions throughout the whole extent of the level. This great resistance requires that a large margin should be allowed for the estimated power to be given to the tow-boat.

"The water displaced by the progress of the boat not having, as in a water-way of great width, room to flow off freely at the sides, is obliged to escape with great velocity through the narrow space between the boat and the sides and bottom of the cut, thus causing a permanent difference of level from stem to stern of the boat, which difference of level is greater as the dimensions of the boat approach those of the canal. In experiments made by us this difference at times was nearly 8 inches.

"The progress of a convoy of boats in a tunnel of great length causes movements in the entire mass of the level. As soon as the convoy enters the tunnel, it presses the water before it, which pressure is transmitted forward in the form of a wave, which traverses the length of the level to its extreme end, from which it is reflected, and returns toward the convoy, reaching which, it passes on to the other extremity of the level, from which it is again reflected, and so on with gradually-diminished height. It is besides clear that any variation in the velocity will create secondary waves similar to this. An increase of the velocity will increase the difference of level, producing a new wave, the motion of which will be in the same direction as that of the convoy.

"On the contrary, a slowing-up of the boats will allow the water to flow backward to attain its equilibrium by passing under the boat, causing a new wave, which will be

* This method permits the chain to be readily taken up or thrown off, which cannot be done if the chain passes over the middle of the boat.—T. T.

† The condenser is absolutely necessary in a tunnel, as, because of the slowness of movement, the escape of the steam immediately produces complete darkness.—M. Bazin.

propagated in a direction opposite to the motion of the convoy. Variations in the section of the canal will also produce effects of the same kind. These causes collectively give rise to very complicated phenomena. We had no very certain data to determine the power necessary for a tow-boat. Some trials made in hauling one, two, and three boats by men in the tunnel and horses in the approach-cuts would seem to give for the value of the effort (F) of traction, necessary to produce a velocity (v) with (n) loaded boats drawing 4'.6 feet,

$$F = 159\, n\, v^{2}*,$$

which, expressed in horse-power, is

$$P = .2890\, n\, v^{3}*.$$

According to this formula, a power of fifteen horses should suffice to tow a convoy of seven boats with a velocity of nearly 2 feet per second. It was even very probable that this result would be exceeded in practice, since it could be affirmed *à priori* that the force of traction should increase in a less ratio than the number of boats in tow."

These estimates have been confirmed by careful experiments, the results of which have been given in Table 1.

M. Bazin, in discussing the results of these experiments "without an absolute rule, which the nature of things does not admit of," groups the results into a very simple, approximate formula, by remarking that the "co-efficient of traction $\left(\frac{F}{v^2}\right)$ of the first boat is about double that of each succeeding one in the same fleet." This formula changed to English weights and measures is

$$P = .2486\,(n + 1)\, v^{3},$$

in which P represents the necessary horse-power; n the number of loaded boats in tow, and v the velocity in feet per second.

The force of fifteen horse-power will then suffice to move eight boats with a velocity of nearly 2 feet per second.

"This formula is evidently but a mnemonic rule applicable to this particular case, since it omits various elements of the question, and notably the most important of all, the relation between the submerged section of the boat and the section of the water-way." [If we suppose the water-way of the Alleghany tunnel to be 31 feet 6 inches at the surface and 30 feet wide at the bottom, with a depth of 11 feet, the conditions will be nearly the same as in these experiments, supposing our boats to be 23 feet 6 inches in width, and to have a draught of 6 feet 6 inches. In fact the section of this tunnel is somewhat greater in proportion to the section of the boat than was the case at the Pouilly tunnel, these ratios being to each other as 357 to 309. Omitting this difference, which will be to the advantage of our calculations, we may apply the data furnished by the Pouilly experiments in the discussions of the Alleghany tunnel.]

M. Bazin, in the memoir referred to, speaks thus of the difficulty of ventilation at the Pouilly tunnel: "All precautions possible had been taken to avoid the production of smoke; the tubular boiler was heated with coke, and a small jet of steam projected under the grate permits an energetic draught to be obtained at will. There exist besides, at Pouilly, nineteen shafts, of little depth it is true, since this depth does not exceed 131¼ feet.

"However, there were all grounds for hope that the ventilation was sufficiently assured. All went well during the first month, but shortly after the crews of the boats were several times seriously inconvenienced. The danger of asphyxia was even sufficiently serious to create fears for the possibility of continuing the service. The volume of gas arising from the combustion of coke was in too small ratio to the volume of air in the tunnel to afford an explanation of these troubles, and the inference was unavoidable that the gas could in certain special conditions accumulate on the tow-boat, and in fact an attentive study of the circumstances very soon showed that such should be the case.

"The air within the tunnel is never in repose. The direction of the wind on the exterior; the difference of temperature of the two long approach-cuts, one of which opens to the south, the other to the north; finally, the influence of nineteen shafts, give rise to currents the direction and intensity of which are continually varying. Frequently several changes in the direction of the currents may be observed in passing through the tunnel, the air ascending at some of the shafts, while at others the air has a downward direction. When the current of air is in an opposite direction to the motion of the tow-boat, the gas issuing from the smoke-stack passes to the rear and disperses; but, on the contrary, when the current has the same direction of motion as the

* These formulæ have been changed to suit English weights and measures; v represents feet per second.—T. T.

boat, it may happen that their velocities may be about the same, in which case the air which envelops the boat follows along with it.

"The gases can then accumulate as they would do in a limited space. There is formed then above the deck a kind of cloud, heavily charged with smoke and irrespirable gases, which accompanies the boat in its progress. This effect is aided, moreover, by the impulse given to the air within the tunnel by the forward movement of the convoy, especially if one of the boats is loaded with a raised cargo, which, in a manner, forms a piston and presses the air before it. Carbonic acid, which alone constitutes nearly the entire volume of gas produced by the combustion of coke, presents of itself no serious danger, unless when mingled in large proportion with the air. But there is also produced a small quantity of carbonic oxide and sulphurous gas, the action of which is very much more to be feared. The carbonic oxide is extremely deleterious, and can even in small quantities produce a real poisoning, of which the first symptoms are vertigo, accompanied with violent headache, weakness in the legs, and sometimes vomiting. The crew of the tow-boat have several times, after traversing the tunnel, felt these effects. However, by carefully watching the fire, taking special pains not to overload the grate when passing through the tunnel, these troubles may be almost avoided.

"The sulphurous acid, notwithstanding its irritating action on the organs of respiration, presents much less danger, but it is impossible to prevent its formation, all cokes containing some traces of sulphur.

"There is also produced a small quantity of sulphureted hydrogen, the presence of which is explained by the passage through the incandescent coke of the small jet of steam used to create a draught. This gas is in part decomposed by the moist air of the tunnel liberating the sulphur, which remains in a state of suspension in the smoke, giving to it a very peculiar milky appearance. When the gas accumulates on the tow-boat, the decomposition of the sulphureted hydrogen even suffices to cover certain objects with a light coat of sulphur powder. The cause of the accidental accumulation of gas being known, by what means can a remedy be applied?

"The only means insuring efficacy would be evidently to establish at the two extremities of the tunnel ventilating furnaces, with movable partitions permitting the current to be reversed at will, so that it might always be opposed to the motion of the boat. This radical solution, admissible in the case of a very important traffic, would have necessitated, unfortunately, at the Pouilly tunnel, sacrifices out of proportion to the very restricted trade, and it became, therefore, necessary to have recourse to means less certain without doubt, but more economical in application. The curbs of the shafts have been raised 9 feet 10 inches above the surface of the ground, and the heavy cast-iron gratings have been removed, which obstructed about half their opening. This modification has sufficed to notably increase the circulation of air in the tunnel. The shafts are 4 feet 11 inches in diameter; their axes are 8 feet from that of the tunnel, so that their openings do not debouche from the crown of the arch, where the gases have a tendency to accumulate. It would then be advisable, in order to render the draught more energetic, to so widen the lower openings of the shafts as to join them directly with the crown of the tunnel-arch. This operation performed at one of them seems to have produced a good result. Another very simple precaution has restored the confidence of the crews, who were much frightened by these accidents, the cause of which escaped them.

"The accumulation of gas being due to an accidental coincidence of motion between the tow-boat and the current of air in the tunnel, it was to be presumed that by arresting the motion of the convoy for a few moments and closing the smoke-stack the current of air would resume its action and dissipate the gas. A trial confirmed this supposition. Instead of accelerating the movement, as was at first injudiciously done by the crew of the tow-boat, a few minutes' detention sufficed for the current of air to carry the smoke and gas far in advance, and it rarely happened that the accumulation again became very troublesome in the course of the same passage.

"An important amelioration, it would seem, might be made in the machine itself; the addition of an apparatus by which the gas issuing from the smoke-stack could be cooled and even purified in part. This might, without doubt, be accomplished by closing the chimney and forcing the gas by means of a bellows into a reservoir, where it would have to traverse a circuit of a greater or less extent in contact with the water of the canal, and then expelled at the surface-level. At present the warm gases tend to accumulate at the crown of the arch, there forming a local atmosphere about the heads of the men employed on the deck of the tow-boat. By expelling them in a cold condition at the water-surface, these gases, for the greater part more dense than the air, would have little tendency to rise, and would become intermingled with the surrounding atmosphere by the movement of the boats. Their contact with the water in the cooler would have the additional effect of dissolving a great part of the sulphurous acid.

"This apparatus, the study of which has been asked of the constructor, not having as yet been established, the amelioration which we indicate has not received the sanc-

tion of experience. However, and although the problem of ventilation has been but imperfectly solved at the Pouilly tunnel, the service has gone on regularly for a year back; and even if the men employed in this service are sometimes a little incommoded the fears which they had conceived in the beginning have been completely dispelled."

M. Bazin, writing January 25, 1875,* says: "The service is performed with a perfect regularity, and it is exceedingly rare that any one is inconvenienced by the gas. This result is due to the experience acquired by the *personnel* and especially by the vigilance of the engineer whom we have had since September, 1868. The personal influence of a good engine-man is capital. The one we had in the beginning allowed matters to take their chances, and it is without doubt to his negligence we must attribute in great part the sad accident which happened in the summer of 1868. This accident, account of which was rendered to the administration, and probably with which you are therefore familiar, took place under the following circumstances: The crew of the tow-boat and even the boatmen found themselves very much incommoded by the gas, which a boat with an elevated cargo contributed to retain on the convoy. The men collected on the tow-boat, detached the tow-lines, and abandoned the boats in the tunnel. Unfortunately they had not been able to bring with them a boatman who was asleep in his cabin. This man, subjected in his sleep to the deleterious action of the carbonic oxide, against which he had not been able to bear up, had lost consciousness, and the others could not succeed in carrying him to the tow-boat. When they returned to the abandoned convoy no further effect of the gas was felt, but the unfortunate boatman, in spite of all efforts, died on the following day without return to consciousness.

"The new engine-man, who has been employed since this accident, is a very careful person, who has himself made successive improvements in the details of the grates, which in the first tow-boat were certainly defective. The intervals between the grate-bars, the dimensions of the openings, have been so modified as always to have a clear fire.

"The first boat sent by M. Claparède had a steam-blast throwing a jet of steam beneath the grate. Perceiving a production of hydro-sulphuric acid, I caused the jet to be placed in the smoke-stack, but the crew made no further use of these blasts, which they accused of having contributed to the previous accidents.

"According to the experience of the engine-man, it is always necessary to enter the tunnel with a clear fire. If they enter with a fire imperfectly lighted and with too much coal on the grate, the action of the blast employed to hasten combustion will be dangerous. It is probable that a too rapid current of air through the flue forces out the carbonic oxide before it has had time to burn. Finally, although the service operates perfectly at present, the question of ventilation has not much advanced. The tonnage which we have to move is too small to render costly experiments possible. I know not whether this question has been more fully studied on the St. Quentin Canal, where the importance of the traffic would perfectly justify the construction of special apparatus.

"Our shafts have little depth. The neck of Pouilly is very depressed, and the maximum depth is 131¼ feet, which is very little for a tunnel so long. The intervals vary from 524 to 656 feet. In the beginning these shafts were located in couples—that is to say, there were in each 656 feet two shafts 131 feet apart. A certain number of them were closed after the completion of the works, and generally there remains but one shaft of each couple.

* * * * * * *

"It is to be regretted that, operating on such a small scale, we cannot undertake a complete study of this question, difficult and now obscure."

In the letter relating to the St. Quentin tunnel, previously referred to, is the following valuable information:

"In 1863 steam-towage with submerged chain, heretofore considered impossible, was inaugurated. Since then it has been successfully organized and perfected. It is at the present time in operation with regularity and success, by means of two tow-boats, each of which traverses twice per day half the summit-level, being about 12⅝ miles going and returning. When a third boat, now in construction, will be finished, the regularity of the service will be perfect, as a tow-boat in need of repairs can be temporarily replaced.

"The long tunnel of the St. Quentin Canal, which extends from Macquincourt to Riqueval, presents a development of 18,603 feet. Shafts located at distances of 100 meters, and numbered from the Riqueval end, were excavated in its construction. The sides of the tunnel are protected by a masonry revetment for 9,515 feet only, being little more than half its length. Throughout the remainder the chalk forms the sides of the gallery. The limestone there is very much affected by the frost, and it has been considered indispensable to stop up all the shafts, and to complete the closure by a system

* Letter to M. Malézieux, transmitted to Professor Andrews, U. S. M. A., for General J. G. Barnard.

of turning-doors, by means of which the tunnel may be closed at the extremities during freezing weather. The ventilation had been imperfect and the employment of steam in towing of boats had been despaired of. It has been accomplished, however, by the following precautions:

"1st. The 9 shafts, Nos. 5, 14, 18, 25, 29, 32, 37, 44, and 49, have been reopened.

"2d. Their upper extremities have been extended by chimneys 3 to 4 meters in height.

"3d. The tow-boat for traversing the tunnel burns coke, and the use of a powerful blast renders the production of smoke almost nothing.

"The shafts are of variable depths, from 130 to 330 feet. Thanks to these precautions, the passage of the tunnel is effected without any person ever complaining of having been inconvenienced. As to the action of frost on the non-revetted sides of the tunnel, its effect is scarcely sensible. When the temperature lowers and the traffic is arrested by ice the doors of the tunnel are closed, and the circulation of air almost ceases."

The experience of these two long canal-tunnels demonstrates a number of important facts. Among the number are:

1st. *That steam-towing has been successful.*

2d. That to overcome the difficulties of ventilation, special devices in the machinery of the tow-boat have been necessary.

3d. That coke should be used.

4th. That it is desirable to have as few steamers in operation as possible at one time within the tunnel.

Special steamers will therefore be necessary, and the boats should move in fleets. This is true, even if the tunnel be wide enough for passing everywhere, or two single tunnels be used. In the latter case, if the boats were to use their own steam-power, there would be with a full trade probably more than thirty boats in each tunnel, all steaming at once, while, if the boats were moved in fleets, there would be but one steamer to each fleet. Besides, these tow-boats would have special appliances to decrease the quantity of smoke and gases, which would be too much to ask of all boats doing business on the canal.

Believing the necessities for special tow-boats to be evident from what precedes, further discussion is not attempted.

To move boats in fleets, the method by submerged chain is undoubtedly the best. There is comparatively little loss of power. The method is very simple in its arrangement. It consists of a chain or cable, (wire,) laid on the bottom, securely attached at the ends, with a tow-boat arranged to maneuver along it.

What is most important, *it has been put to the test* of actual experience, and is therefore not at all experimental. In France this method has received extensive application on the rivers, and is also in use in a portion of the Erie Canal, under the name of the Belgian system of towing.

My opinion as at present formed is in favor of using a chain, on account of the facility of repair. A break in a wire cable would require an expert to splice it. This would be difficult to do if there were not considerable slack available, as there would not be in this instance. The chains used are made in sections, connected by links, which may be readily opened. The section containing a broken link may then be removed at any time, and a new section put in its place. A supply is always kept on the tow-boat for emergencies.

For greater security I would recommend that the tow-boat be provided with a pulley on each side, and that two chains be laid on the bottom at a distance apart equal to the width of the tow-boat. This would be very necessary in a tunnel with a current, so that if one chain broke the fleets would still have one to hold to; otherwise all the boats eastward of the break would be washed into the basin of the eastern approach. The chain has the further advantage of greater friction on the bottom, as compared with the wire cable.

The chain will have an important use in assisting, by the application of proper brakes, the retardation of the descending fleets preparatory to hauling them into the recesses. Two chains will be advantageous in this maneuver. The chain always has a tendency to draw to the inner side of a bend, and if it did do so would prevent the progress of the tow-boat. A rapid current corrects this tendency, or, if the water-course be wide, the steering power of the boat will compel the chain to remain in the channel. Within a tunnel we can depend on neither of these aids, and there must be no tendency of this kind.

PERFECT STRAIGHTNESS IS NECESSARY.

Attention is now invited to sheet No. 1 of the summit division. Mr. Hutton's proposed tunnel of 1870 is laid out on a curve, so as to decrease the depth of shafting, by placing them farther toward the valley than the surveyed or experimental line. By increasing the depth of shafting, this location could be made perfectly straight. No straight line can be located within the limits of the survey of 1874 from Brush Creek

to the Greenbrier River direct without great depth of shafting or great distances between them. From the initial point of this direct line (designated Northern line, 1874) to the south fork of Howard's Creek the ravines fall to the north of the line, and a very good location can be obtained on that side, straight to the Greenbrier Mountain. The best line for tunneling this mountain is by way of the two ravines immediately south of the line. But this line makes an angle with any straight line from Brush Creek to the Greenbrier, and is therefore not available for our purposes. If we limit the depth of shafting to about 600 feet, the best straight line through here is from Brush Creek to a point in that ravine debouching into the valley of Howard's Creek, north of the line, and heading near station 507 + 33. We would have on this location one shaft (eastern) 600 feet in depth, and one (western) 520 feet, with a distance between of 9,450 feet.

Estimating 30 feet per month for shaft-excavation, and 100 feet for tunnel-heading, the time of completion would slightly exceed sixty-six months. The length of the tunnel would be about 50,500 feet.

On the southern line, from Brush Creek to the south fork of Howard's, the ravines fall to the south. Beyond the railroad, there is a ravine south of the line, heading near station 368 + 50. On the other side of the crest the ravines fall to the north, but shafting may be obtained south of the line, and lower down the ravines than for Hutton's location. A straight line may then be obtained from Brush Creek to Howard's Creek, south of the surveyed line. This line is chosen for the following reasons: It has much more advantageous shafting than either of the others as to depth, distance between shafts, and proximity of location to railroad; it requires about 9,000 feet less tunnel than the line from Brush Creek to the Greenbrier direct, and while the tunnel is somewhat longer than Hutton's proposed tunnel of 1870*, there is saved more than 13,000 feet of canal on the eastern slope.

The necessity of towing the boats through the tunnel in fleets being admitted, there must be a basin of suitable dimensions at each end. As the line must enter the valley of Howard's Creek below the level of the stream, on account of water-supply, the basin at this end is readily obtained by building a dam at a proper point, and a basin may be obtained in Brush Creek Valley in the same way.

The elevation of the tunnel, which is the summit, should be now fixed. The elevation of 1,700 feet above tide was recommended by Mr. Lorraine, and adopted for Hutton's location of 1870. On account of the expensive approach in Howard's Creek, it has been suggested to raise the summit 20 feet. (See Mr. Latrobe's letter to Chief of Engineers, supplementary to the report of the board of engineers, March 19, 1874.)

Various considerations enter the discussion of this question. If the lower level be adopted, the basin in Brush Creek Valley (see sheet No. 2, summit division) may be formed by a dam a short distance below station 77 + 50, and the tunnel should debouch near the upper end of the pool. This pool will have about 1,800 feet effective length; its total length will be somewhat more. If the higher level be chosen, the dam may be located at station 89, giving a pool of about the same effective length as the other. There is scarcely enough difference in the capacity of these pools to have weight in the decision. A basin of necessary capacity for either level may be obtained in Howard's Creek.

The valley of this creek (see sheet No. 3, summit division) below Hart's Run to Caldwell's station is narrow and tortuous. Near the point where Hutton's line of 1870 debouches is a rock-spur 80 to 100 feet above the valley, and causing it to make an abrupt bend. From station 582 + 47.8 up the valley, for about 1,000 feet, high ground, having the character of a bluff, comes very close to the line. The level of the creek near here is about 1,744 feet—too high to permit it to enter the canal at the higher level. For either level, the cutting will be deep and long. It must also be wide if it pass around the bend; in which case the creek should be passed through the spur. To avoid this, I recommend that the creek be passed over the cut, and that the spur be tunneled for the canal. The canal and creek will then connect below. If we suppose the creek-bottom 4 feet above the crown of the aqueduct-arch, and that 20 feet be as little as can be admitted between the water-surface and the crown, then the water-surface can be no higher than (1720.) This is, therefore, taken as the superior limit of the elevation of the summit [*i. e.* with "canal bottom" at (1713.)]

We can now locate the tunnel-lines for these two levels, (1713) and (1700.) It is desirable to have the approach cut in the valley of Howard's Creek straight, and in the prolongation of the tunnel, so that the cut may be no wider than the tunnel and the towage by submerged chain may be used from one basin to the other.

The low bluff above station 582 + 48 should be avoided, and in Brush Creek Valley the tunnel should debouch so as to utilize the basin corresponding to the level taken. The eastern portal for the (1700) level is taken near the upper extremity of the 1700 curve. The entire pool will then be below. Line "A" is the line recommended for this level. For the (1713) level line "B" is recommended. This line has almost the identical

* Hutton's tunnel is 40,3?0 feet in length. The tunnel now recommended is 41,505.

location of approach in Howard's Creek as the (1700) level, (see sheet No. 3, summit division) but debouches in the valley of Brush Creek at the upper extremity of the (1720) curve. These lines, as shown on sheet No. 1, are the lines of shafting. If the lower level be taken, it is intended the tunnel and approaches shall be north of the shafts, while the opposite is intended for the higher level.

The basin in Howard's Creek Valley is formed in each case by a dam just below station 106 + 73 of the Howard's Creek line.

Each of these lines has advantages and disadvantages peculiar to itself, and it is thought best to place a statement of them side by side the better to judge of the merits of each.

Upper level.	*Lower level.*
Length of main tunnel, 41,505 feet.	Length of main tunnel, 43,040 feet; being 1,540 feet longer than for higher level.
It is probable that shaft No. 6 of this line is unavailable from depth and difficulty of approach.	By using shafts Nos. 2, 6, and 7 of this line, the tunnel may be excavated in 50¼ months.
By shafts *bis*, and 7, the excavation will require 57¼ months.	By shafts 5 *bis*, and 7, the excavation will require 59¾ months.
By shafts Nos. 5 *bis*, and 8, the excavation will require 62.13 months.	By shafts Nos. 5 *bis*, and 8, the excavation will require 64¾ months.
By shafts 1 and 3 *bis*, Lewis Mountain will be tunneled in 47.5 months.	By shafts 1 and 3, Lewis Mountain will be tunneled in 51¾ months.
By shafts 1 and 3 *bis*, Lewis Mountain will be tunneled in 48¾ months.	
Pumping will stop at shaft No. 1 in eleven months, and the eastern heading of Lewis Mountain will be open to the portal.	The eastern heading of Lewis Mountain will not be open to the portal till the end of the twenty-second month. This is quite an advantage to the upper level.

It is thus seen that, for time of excavation, the only apparent advantage possessed by the lower level, exclusive of lockage, is the availability of shaft No. 6, and less time for the excavation of the headings between shafts Nos. 3 and 4, and between shafts Nos. 4 and 5, or 5 *bis*. In the estimates made for times of excavation, 30 feet per month is allowed for shaft-excavation, and 100 feet per month for tunnel-heading. These rates of progress are taken the same whether the headings be driven from deep or shallow shafts or from a portal.

By omitting shaft No. 6, the upper level has the advantage in time of excavation, which it retains, if shafts Nos. 7 and 2 be omitted.

In considering how far the omission of these shafts will delay the execution of the work, the experiences at other works of this kind are interesting.

Mr. H. D. Whitcomb writes me as follows, relating to the Great Bend Tunnel: "I do not know that I found any difference in penetrating from shafts or portals. So long as the hoisting-power is sufficient, there can be no material difference." (He states very little water was found.)

The earlier progress of the Hoosac Tunnel affords no criterion of the progress to be here expected, and we can only use the results from the time Messrs. Shanly commenced operations in 1869. The central shaft was already excavated to a depth of 583 feet, leaving 445 feet to grade. Work commenced here May 20, 1869, and the excavation reached grade August 12, 1870, in little less than fifteen months, the rate being 30.1 feet per month.

When it is considered that this progress was in the lower half of a shaft 1,028 feet deep, it may well be assumed that the excavation will be much more rapid in the shafts of the Alleghany Tunnel, especially in those shafts less than 300 feet in depth. In the Hoosac Tunnel, 1869, the average monthly progress from portal-headings was 137.7 feet; in 1870, 119.3 feet; in 1871, 130 feet; in 1872, 133 feet; and in 1873, 135 feet.

Two and four-tenths months were employed, after the shaft was sunk, in preparations for the tunnel-extension, such as trimming the sides of the shafts, repairing and strengthening the timbers and girders, in the removal of the pipes and pumping-machinery provided by the State which were used while making the shaft, and the replacing them by mains and pumps of larger capacity. Much of this time might have been saved had the original preparations been adequate. The shaft, as has been stated, reached grade August 12, 1870. Owing to the above delays and the breaking of machinery, only 60 feet advance was made at one heading from this shaft, and 87 feet at the other heading, to January 1, 1871. During the next year only 277 feet were driven from one of these headings, and 153 feet from the other. In 1872, better progress was made, at one heading 1,226 feet being driven, (in 11¾ months,) while but 119 feet advance was made at the other. "The advance of this heading was suspended during more than ten months of the year, by reason of enforced delays arising out of the large volume of water encountered, and an apprehension of developing a further increase of

quantity, which would exceed the resources of the pumping-machinery provided for its removal."*

It will be seen that the progress at one heading was a little more than 100 feet per month, and it probably would have been as rapid at the other, had it not been for the fear of water, or had sufficient pumping-machinery been provided. Even the former shows much less progress than the portal-headings. Shafts 2 and 6 are more difficult of access than Nos. 1 and 5, or 5 *bis*, and preparations could not be made at the former as soon as at the latter.

Referring now to the profile of line A, (sheet No. 1, summit division,) we see that by our original assumption the headings between shafts Nos. 5 and 6 will meet at a point 1,343 feet from the latter, and shaft No. 6 will be used for the excavation of 2,686 feet of tunnel to this time.

If shaft No. 5 *bis* be used, instead of No. 5, the headings will meet 93 feet from shaft No. 6, and only 1,866 feet will be excavated by means of this latter shaft up to this time. The time saved by the use of shaft No. 6, as computed, is nine and one-fourth months, but the practical saving would undoubtedly be less than this, on account of the greater accessibility of the shorter shaft and greater liability to accidental contingencies of the longer one.

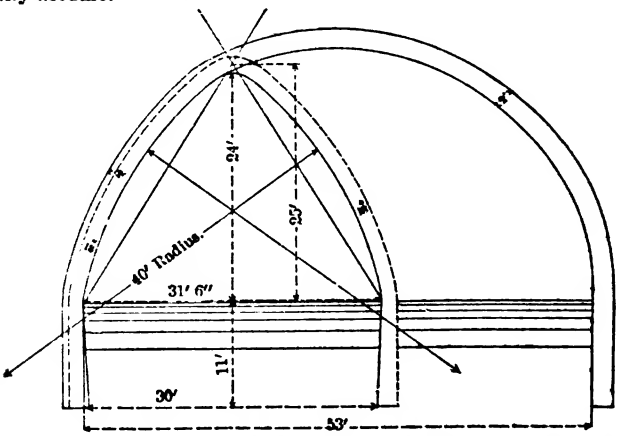
Merely as a matter of opinion, I would say the real saving of time would be about 6 months.

We will assume 6 months' saving of time. Shafts No. 5 *bis* and 7 of line B differ little in their circumstances from the corresponding shafts of line A, the former being 20 feet less in depth, the latter 40 greater. The computed difference in time of excavation is 2¼ months in favor of line B. We will call it 2 months, omitting the ¼, as the advantage which shaft No. 7 of line A has over shaft 7 of line B. Line A would then have but 4 months' advantage over line B in time of execution in the tunneling of Kate's Mountain. Assuming equal progress at all shafts and all headings, the headings between shafts No. 1 and No. 2 of line A would meet at a point 683 feet from shaft No. 2, and 1,366 feet of tunnel up to this time be excavated through this latter. The time saved by this shaft is computed at 6.83 months. If we suppose the same decrease of time saved in practice as was assumed for shaft No. 6, line A will present no advantage whatever in the time of tunneling Lewis Mountain over line B, even if we suppose shaft 2 to be used in the former and omitted in the latter.

The short tunnel in Howard's Creek Valley is 56 feet longer for the lower than for the higher level.

The final determination of the cross-section of the tunnel should now be made.

If passing-places be decided upon, that fact should be taken into consideration. That the towing should be by submerged chain is assumed. The boats should then follow the axis of the tunnel, and the widths of turn-outs should be sufficient to admit of boats passing easily. The width of boats is taken at 23 feet 6 inches. For the main tunnel section, the printed form, as suggested by Mr. Latrobe, is the best, affording good heights, with least excavation, besides being the shape which the excavation will naturally assume.



Our estimates for the power necessary for the tow-boat have been made for a supposed water-way 31 feet 6 inches in width at the surface and 11 feet deep. With these data, the adjoined diagram of section at turn-out is constructed.

* Report of standing committee on the Troy and Greenfield Railroad and Hoosac Tunnel for 1872.

The height of the crown of the main tunnel is assumed 24 feet.

One-half the width of the main tunnel section is	15'.9"
One-half the width of boat is	11'.9"
Clear space between boats	1'.9"
Width of boat in recess	23'.6"
Wooden fenders built in the wall of recess (to preserve boats from injury by the waves) projecting	0'.3"
Total width (water-surface) at recess	53'.0"

This is, certainly, as little width as can be given with the assumed widths of boat and of main tunnel.

Cost per foot of ordinary tunnel—		Cost per foot of recess—	
Brick	$56.66666	Brick	$79 20
Stone	12.21629	Stone	13 04
Excavation	182.77777	Excavation	242 95
	251.66074		435 19
			251 66
Excess of recess over ordinary tunnel			183 53

This section is taken as the basis for estimates.

The lower level exceeds in cost the upper level by the following items:

1,591 feet of tunnel, at $251⅔ per foot	$400,401 67
252,415.82 cubic yards of rock-excavation, at $1 per yard	252,415 82
75,159.74 cubic yards of loose rock-excavation, at 50 cents per yard	37,579 87
1,140 feet of shafting, (10 by 40 by 1,140,) 16,888,889 cubic yards, at $10 per yard	168,888 89
358.82 cubic yards of dam-masonry, at $8 per yard	2,879 81
Total	862,157 06

This is partially offset by the following items, in which the upper level exceeds the lower in cost:

9,714.17 cubic yards embankment, at 25 cents	$2,428 54
8,635.35 cubic yards excavation, at 30 cents	2,590 60
12,888.90 cubic yards lock-masonry, at $9	116,000 10
Lumber for 7 locks, at $3,400	23,800 00
Gates and miter-sills, at $3,150	22,050 00
Total	166,869 24

The cost of the lower level we see to be nearly or quite $700,000 in excess of the higher, while the saving in the time of excavation will be, at the outside, but 6¼ months.

Considering the cost of the entire line, I do not think the lower level to possess sufficient advantages to balance this excess of cost, and the level of 1,713 feet above tide is therefore recommended.

If the boats be passed through the tunnel in fleets and turn-outs be adopted, the times of departure should be at equal intervals. The proper intervals between the departures of successive fleets should be established before determining the number and dimensions of the turn-outs. The convenience of commerce requires that it be as short as possible, while the minimum expenditure of power requires that fleets be as large as can be handled easily. We will suppose the interval to be two hours; assuming eight lockages in this time in each direction, the fleets will consist of eight boats. Two fleets will then emerge each two hours, (one from each portal.) In the formula $n = Nv$, N will then equal unity; n will conform to v. For economy of power the rate of movement should be slow, while economy of construction requires that it should be rapid.

The following table (IV) is formed by reducing the velocities in Table I to 1 mile per hour, assuming the resistances to vary as the squares of the velocities, and taking the supposition as correct that the resistance for the first boat per unit of submerged section is double that per unit for the succeeding boats of the same fleet. Experiment 6 is omitted, as the fleet was formed of rafts.

TABLE IV.

Number of experiment.	Number of loaded boats.	Letter for reference.	Area of submerged section of leading boat, square feet.	Sum of areas of submerged sections of following boats.	Total submerged area = twice fourth column added to fifth column.	Estimated force of traction (total) for 1 mile per hour.	Estimated force of traction per square foot of total submerged area for 1 mile per hour.
1	1	A	64.04	....	128.03	500.1	3.905
	1	B				598.5	4.665
	1	C				490.6	3.832
2	1	D	72.12	....	144.24	590.4	4.094
	1	E				519.3	3.600
3	2	F	68.89	57.05	194.83	564.8	2.899
	2	H				608.5	3.123
	2	I				599.6	3.077
4	2	K	65.66	73.73	205.05	760.6	3.709
	2	L				693.7	3.383
5	2	M	69.96	87.19	227.11	634.4	2.793
	2	N				793.6	3.494
	2	O				656.2	2.889
7	3	T	71.04	130.78	272.86	1,048.6	3.843
	3	U				1,021.5	3.744
8	3	V	72.66	135.63	280.95	1,036.8	3.690
	3	W				1,171.9	4.171
	3	X				1,151.6	4.099
9	7	Y	74.47	401.50	550.44	1,906.7	3.464

The arrangement of this table has made apparent a fact which had escaped attention before, viz, that in those experiments in which three results are given, the second shows invariably a greater resistance than either of the others. The direction of movement of the different boats or fleets was the same in all, and the second result refers to the middle of the tunnel, where the resistance was then greater than at either end. In the second, fourth, and seventh experiments, the first velocity and resistance noted were near the middle of the tunnel, the second nearer the farther end, thus confirming the indications of the first, third, fifth, and eighth experiments.

In the ninth experiment the space passed over was from near the middle to near the end. It is necessary, therefore, in discussing the results of such experiments, to consider this fact, and not to compare the data furnished from different portions of the tunnel with each other. *It is to be inferred that if the tunnel were longer, the resistance near the middle would be still greater than here noted.*

Considering the small number of experiments, this table demonstrates in a remarkable manner the deduction of M. Bazin from Table I, which is, that the co-efficient of resistance for each boat following the first in a fleet may with safety be taken as one-half this co-efficient for the first boat.

The third part of the eighth experiment is apparently an exception to this rule, but in this part the point of departure was 640 feet nearer the middle of the tunnel than the point of departure for the third part of the first experiment, though the terminus was the same in each case.

An inspection of Table IV would seem to show that in our calculations for the power necessary for our tow-boat, we may assume 5 pounds resistance per unit of total submerged area [$=(8+1)(23'.5\times6'.5)=1374.75$,] and the total resistance for 1 mile per hour $=6873.75$. With the proposed area of water-section, I estimate that the current through the tunnel would be one-third mile per hour to feed the canal east of the summit-level. If we suppose that one-third mile per hour will be necessary, in addition, to overcome this current, there will be required 12,220 pounds total traction.

Labrousse deduces the following formula for the useful effect of traction with submerged chains:

$$r=\sqrt{\frac{255-H}{255}}$$

H represents the depth of water in meters, but is really the vertical distance from the bottom to the point where the chain leaves the pulley. We will be safe to as-

sume this distance at 5 meters. The tension of the chain as it leaves the pulley (which is the resistance to be overcome by the machine neglecting its own friction) is then 12,338 pounds. The work of the machine at this point will be, say, 44.1 horse-power.

In these estimates the resistance of the tow-boat itself has been neglected, but we have considered the westward-bound boats alone, and supposed each to be loaded to 6 feet 6 inches. It is probable that the draught of even heavily-loaded boats will not exceed 6 feet 4 inches, and many of the westward boats will be lightly loaded.

I think two-thirds of the above estimate of total submerged area are to be sufficient for westward fleets. The actual velocity of 1 mile per hour being obtained, one turn-out per mile will be necessary.

At times, if sufficient water flows in Brush Creek after heavy rains to supply temporarily the quantity necessary for the canal to Dunlap's Creek, (in which the water will also be high,) there will be no current in the tunnel, and the formula $n = N(v + n\,t)$ must be satisfied. Substituting for n and N their values, we have $v + t = 1$; that is, the time of passing from one turn-out to another, (being one mile apart,) added to the time lost at a turn-out, must not exceed one hour. We have calculated the resistance for $1\frac{1}{3}$ miles per hour; v will then be $\frac{3}{4}$, and t must not exceed $\frac{1}{4}$ of an hour, or 15 minutes. This would seem ample time for the maneuver at the turn-out in still water.

The next thing to be considered is whether the strain may not exceed the strength of a chain of ordinary dimensions. If we neglect the friction on the bottom, the greatest strain occurs when all the fleets moving in the same direction are alone using the chain. This will happen when the eastward fleets are all in the turn-outs at once, which may frequently occur. We must then provide sufficient strength for 5 fleets. A chain employed on the Upper Seine* is made from 0.886-inch iron, and sustained a test-strain of 26,448 pounds before use. This chain weighs about 7.6 pounds per running foot.

Lagrené assumes the friction equal to one-half the weight of the chain; about one-seventh must be deducted for loss of weight in water. The friction would then be more than $3\frac{1}{4}$ pounds per running foot, aggregating 16,926 pounds per mile. The distance between fleets would be 2 miles, and, therefore, the tension would become zero before half this distance were reached, as we have found the tension for each fleet to be 12,220 pounds.

Labrousse mentions an instance in which, if we suppose a force of traction of 2.2 pounds necessary on an open canal for each ton with a velocity of 3.28 feet per second, the friction must have been 0.58 of the weight of the chain on the bottom. Or, supposing this force of traction but 1.1 pounds, the friction would be 0.29 of this weight. Under this latter supposition the resistance would aggregate 20,365 pounds in the distance between 2 fleets, and the tension would become zero in about 6,332 feet ahead of each tow-boat. It is, then, more than probable that the tension necessary on the chain will at no time exceed the tension necessary for one fleet, which we have seen is less than 50 per cent. of the test-strain of the chain in use on the Seine.

The strength of the chain is then an assured matter, assuming the net velocity of movement at one mile per hour with 8 boats in tow. Assuming four lockages per hour as the maximum trade to be provided for by turn-outs, we will now compare the 2-hour interval with others, viz, 4, 3, $1\frac{1}{2}$, and 1 hour intervals, supposing the tow-boats in each case to work to 44.1 horse-power, (effective.) Table V shows this comparison.

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* Lagrené.

TABLE V.

Intervals, in hours, in departure of fleets.	Number of boats in fleets.	Length of fleet, supposing each boat and tow-boat to occupy 120 feet.	Add one-tenth for free space to obtain length of turn-out.	Computed velocities, in miles, per hour.	Net velocity, supposing one-third mile per hour necessary to overcome current.	Tension of chain, in pounds, as it leaves pulley.	Intervals between recesses, in feet, from center to center.	Number of turn-outs within tunnel, (upper level.)	Number of steamers within tunnel at one time.	Aggregate length of recesses, in feet.	Excess of cost over ordinary tunnel-section.	Excess of cost over cheapest arrangement.
Four	16	2040	2244	1.08117	.64784	15,331	6847	6	7	13464	$2,484,511 92	$1,023,034 32
Three	12	1560	1716	1.1823	.7890	14,0[illegible]9	6249	6	7	10496	1,899,920 88	438,452 28
Two	8	960	1056	1.373	1.040	12,338	5280	8	9	8448	1,558,900 44	97,421 84
One and a half	6	840	922	1.4553	1.1220	11,407	4435	9	10	8298	1,531,229 94	69,752 34
One	4	600	660	1.6258	1.2933	10,195	3414	12	13	7920	1,461,477 60	....

It is thus seen that for this power of tow-boat, economy of construction is on the side of small fleets or short intervals. The 3 and 4 hour intervals are rejected. We can provide for the assumed trade with this expenditure of power by either of the three latter intervals, and with little difference of cost; for the 2 hour interval will require 4 less steamers, and the 1½-hour interval 3 less steamers than the one-hour interval. The original cost of these steamers, with wages of crews, running expenses, and repairs, will go far to remove the inequality. It may be interesting to note the phase the question takes by assuming the same tension of chains for the three latter intervals; the tension assumed is that for the 2-hour interval, 12.358 pounds:

Intervals of departure.	Computed velocities, miles per hour.	Net velocities, miles per hour.	Effective horse-power necessary.	Intervals between recesses from center to center, in feet.	Number of recesses within tunnel.	Aggregate length of recesses.	Excess of cost over ordinary tunnel-section.
Two	1.3333	1.000	44.4	5280	8	8418	$1,558,909 44
One and a half	1.5114	1.1782	49.6	4666	9	[illegible]	1,531,239 94
One	1.7583	1.4550	58.7	3832	11	7260	1,339,087 80

Under this supposition, the 2-hour and 1½-hour intervals remain the same in regard to cost. The cost in the 1-hour interval is reduced $122,389.80, the number of steamers necessary is reduced by 1, but the power of each tow-boat is increased 14.6 horse-power. If we suppose the friction one-half the weight of the chain on the bottom, it would amount in the distance between fleets to 13,123 pounds with the chain in use on the Seine, being but 765 pounds more than the tension assumed. Deducting the amount of chain raised from the bottom by the tow-boat, these two forces would be about the same. But if the friction should be less than one-half the weight, the surplus tension would be transmitted forward, and the accumulation from the different fleets might be more than a proper chain should be subject to. High velocities with short intervals should on this account be avoided. Low velocities with short intervals effect no saving in cost, while rendering ventilation more difficult because of the greater number of steamers required.

All things considered, the 1½-hour interval with the lower power is recommended as the arrangement to be adopted in the method by fleets and passing-places. It requires 1 more steamer than the 2-hour interval, but a higher velocity can be more safely and easily obtained should it become necessary from any cause; and the saving of time will amount to a good deal in a year's trade, sufficient to provide for the greater difficulty of ventilation, should a difficulty of this kind arise.

By spacing the turn-outs at distances of 4,435 feet, as required by Table V, beginning at the eastern portal, the ninth turn-out will be about 1,700 feet inside the west portal, the tenth will be between the first and second crossings of Howard's Creek, and the eleventh will be within the short tunnel. The proper place for this last turn-out, being the first approaching from the west, is below the short tunnel, where the boats will naturally collect and form tows. If this turn-out be placed here, and eleven turn-outs be used, one of two alternatives must be adopted: either the turn-outs must be placed farther apart than 4,435 feet throughout the line, or one turn-out must be located between the main and short tunnels, and the open cut be made sufficiently wide to decrease the resistance, so that sufficient speed may be obtained here to make up for the greater distance between turn-outs. This first is not advisable. The second is more expensive than the excavation of an additional turn-out in the open cut. Accordingly the first turn-out from the west, which is but a harbor for the formation of fleets, is placed below the short tunnel; the third is immediately outside the west portal of the main tunnel. Nine turn-outs will be necessary within the long tunnel. There is sufficient available space in a straight line outside the east portal for the formation of a fleet of six boats, still it is desirable that it should not be necessary for the fleet just formed to enter immediately on the exit of the eastward boats. It is well to have a margin of time to remove the eastward boats out of the way; to attach the westward tow-boat to the chain, and to assure a proper condition of its fires before entering. To provide this margin of time, the first turn-out from the east portal should be at a less ditance from the portal than the distance between turn-outs. By spacing the turn-outs at distances of 4,350 feet from center, to center, which is 85 feet less than required by Table V, beginning at the turn-out just outside the west portal, the conditions seem to be fulfilled in a reasonable manner.

The second turn-out in Howard's Creek Valley is located above the aqueduct for pass-

ing the creek over the cut and on the side opposite the creek. The creek is to be turned into the sloughs about opposite the portal, and where necessary the earth excavated from the tunnel-approach will be formed into a dike to prevent floods from flowing into the cut. The cut is to be arched over for a distance of 1,200 feet above the short tunnel, to pass Howard's Creek and its floods. The dike will terminate at the upper extremity of this arching. The connection of the creek and canal below the short tunnel is to be made as follows: The creek-bed will be excavated for 600 feet up-stream to a width of 80 feet, the lower half to the level of canal-bottom, the upper half to the level of the comb of the dam below, viz, 1,721. Across the lower end of the upper half will be a dam 5 feet high, which may be natural if the rock be met with and will permit it. This dam will have a gate, which may be opened at low water, permitting the artificial pool above to be drained off, when the sand and gravel brought down by the creek and there deposited may be removed.

A supporting-wall for the movable materials for the creek-bed above will probably be necessary to keep them out of the catch-gravel pool.

The Howard's Creek dam is located below Caldwell Station, where the valley widens out as it approaches the Greenbrier. This location, though requiring a dam about 40 feet in height, seems to be the best. I at first thought of adopting a location near station 67 + 71.2, which would require a dam about 15 feet high. But this would render necessary the constructing of more than 1,200 feet of feeder over very bad ground.

In leaving this dam one of two methods might be adopted:

1st. A guard-lock at the dam on the left of the valley; then a cut not less than 30 feet deep for a quarter of a mile, and an aqueduct over Howard's Creek.

2d. Lock down from dam on the left and enter, near the mill, the pool of a dam located at the adopted site.

Either of these, with the extra feeder-canal, would undoubtedly be more expensive than that recommended. A flight of two locks is necessary at the dam.

The canal joins the Greenbrier division in the pool of a dam, description of which will be given in the report of that division. The lock at the Greenbrier is 14 feet lift.

There will be required east of the summit the following amount of water:

	Cubic feet per minute.
Evaporation and filtration, sixteen miles, 200 cubic feet per mile per minute..	3,200
Lockage, (supposing six lockages per hour and one lock-full to each,) = [14 × 24 × 120] × 120 equal 241,920 cubic feet per hour........................	= 4,032
Waste at structures..	= 500
Leakage at gates..	= 2,
Total..	9,732

McNeil found the minimum flow of Dunlap's Creek to be 9.43 cubic feet per second = 565.8 cubic feet per minute. The tunnel at the time of minimum flow would be required to deliver 973[illegible] − 565.8 = 9153.2 cubic feet per minute. The area of its water-way is 338.25 square feet, and the velocity, therefore, should be 27.1 feet per minute, say ⅓ mile per hour, (= 29⅓ feet per minute, delivering 9,709 cubic feet per minute.)

The distance from Howard's Creek dam to Brush Creek is somewhat short of 60,000 feet. The fall necessary in this distance for a velocity of 30 feet per minute is ½ of a foot, nearly. To provide for this fall, and also to correct in a degree any irregularity of feeding, the comb of the dam in Howard's Creek is established 8 feet above canal-bottom—*i. e.*, at reference, (1,721.) The comb of the dam in Brush Creek Valley is to be one foot higher than this, to prevent excessive waste of water over it by the waves formed by the eastward fleets. The top of the lift-wall of the first lock is on a level with the bottom of the tunnel, so that navigation may not cease as long as there be sufficient water therein to float a boat. This will still further tend to correct irregularities of feeding.

The conformation of Brush Creek Valley requires that the locks for entering and leaving the basin should be on the hill-side to the right of the dam, while the canal should be on the left of the creek, below station 77 + 50. Accordingly, a dam is located near station 77, from the pool of which the boats leave by a flight of three locks. To prevent waste of water, the comb of this dam is 8 feet above canal-bottom. The flights of locks at both dams are double. The lift of all locks in Brush Creek Valley is 8 feet. The levels are necessarily short, and the overfalls should be so arranged as to retain rather more than the necessary depth of 7 feet. Through a good part of this distance, a dike will be necessary to restrain the floods of Brush Creek. This dike, also serving the purpose of embankment to the canal, should be several feet above the creek-bed. For this reason, the excavation in this valley is generally of little depth, which permits the levels to be wider than the ordinary canal, making up somewhat for their little length.

The connection with Lorraine's location is made in a pool in Dunlap's Creek. I

would recommend the pool of this dam, as well as the others in Dunlap's Creek, to be 8 feet above canal-bottom, to prevent waste of water and to correct irregularities of feeding. A riprap protection is estimated for on the upper part of the dike, where the channel-way of the creek is somewhat restricted in width. Below the last lock, a loose-stone breakwater is provided on the up-stream side, to protect the boats at the tail of the lock from the current in Dunlap's Creek during high water.

The feeding arrangements are next to be considered. The maximum lift of lock east of the summit is 14 feet, which is also the lift of the lock connecting the summit with the Greenbrier division. Taking this lift as the unit of lockage, supposing 6 lockages per hour, each requiring two locks full of water, there will be required each hour for

lockage, (2 × 6) (14 × 24 × 120) = 483,820 cubic feet, equal.	8,064 cub. ft. per min.
Evaporation and filtration, 28 miles, at 200 cubic feet per mile.	5,600 cub. ft. per min.
For leakage at lock-gates	4,000 cub. ft. per min.
Waste at structures	1,000 cub. ft. per min.
Total	18,664 cub. ft. per min.

Say, 320 cubic feet per second as the quantity to be delivered at the summit by the feeder, if we neglect the flow of Howard's and Dunlap's Creeks.

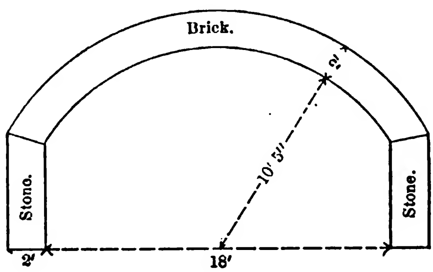
Mr. Hutton's proposed location for feeder-dam for the (1,700) level is near the mill-dam above dam A, (Sheet No. 4, summit division.) From there the feeder-canal was proposed to keep to the hill-side on the left of the valley, and to pass round the point near the Greenbrier bridge, uniting with the canal below station 106 + 76 of the Howard's Creek line. (Survey of 1874.)

Mr. Latrobe suggested the adoption of a feeder-tunnel through the point about opposite station 115 + 05 of Howard's Creek line. An examination with this view of saving feeder-canal by tunneling the point, led to the discovery of the cut-off by the ravine from the Greenbrier, between dams Nos. 1 and B. A tunnel here 1,340 feet in length will save at least 7,600 feet of feeder on very bad ground, besides 7.6 feet in height of feeder-dam.

The location for a feeder-dam at the bluff, near dam B, is not available for the 1,713 summit at least. For this level the dam would be about 50 feet in height, with a guard-bank more than 1,500 feet in length, the river-end of which would be about 60 feet high. The pool would be of no use as a reservoir, for, of course, the water could not be drawn off below the level it is intended to supply. The location near station 108 is recommended. No guard-bank will be required and no valuable ground will be overflowed.

The normal level of the water-surface on the summit is 1,720 feet. This level is taken as the bottom of the feeder, where it discharges into the Howard's Creek pool, and the slope of the bottom is assumed at one foot in one thousand feet.

A rectangular section (18 × 5 = 90 square feet) is adopted as the standard. This with a slope of $\frac{1}{1000}$ will give a velocity a little in excess of 4 feet per second, delivering 360 cubic feet in that time. The sections of the feeder-tunnel at the Greenbrier end are shown by the figure annexed.



The arch is horizontal and the bottom falls for the necessary slope. A dam is proposed across the ravine at the Greenbrier end of this tunnel, which will provide a waste-weir at this point. The bottom of the tunnel at this end will be 1,721.5 above tide. Five feet of water will make the surface-elevation 1,726.5. The top of the waste-weir is established at 1,727, and the feeder-bottom at station 24 is taken 1,722.

The dam should have a gate so arranged that the pool may be drained, and the sediment brought down by the feeder washed into the river.

The excavation to the ravine above dam A will be mostly in red shale. The cross-section at station 24 may be taken as the type of this portion. It is recommended that a wall be built on the river-side 7 feet in height (see cross-section station 21) and 3½ feet in width, resting on a foundation of concrete 2 feet thick, and that the exca-

vation be made 18 feet in width on the bottom. The blue line from waste-weir to feeder-dam (Sheet No. 4, summit division) is the outer edge of feeder-bottom. Eleven culverts will be required on the feeder-line.

The wall on the river-side of the feeder ends at station 72 + 50. Above this for some distance embankment is considered preferable in view of expense. To prevent excessive waste of water from the feeder the following is recommended: The excavation to be made 1 foot below feeder-bottom, then about 9 inches of puddle-clay carefully laid on this, about 2½ inches of stone, broken small, to be laid and lightly rolled, then a layer of hydraulic mortar to be thrown on and rammed carefully, so as not to disturb the broken stone. I should fear that puddling alone would be washed away by the current. The inner slope and outer slope (when embanked) to be paved to 7 feet above bottom.

Paving to be 6 inches thick, laid in mortar.

ANALYSIS OF COST PER RUNNING FOOT.

One-sixth yard broken stone, at $1	$0.17
One-half yard puddling	0.25
One-quarter barrel cement	0.40
Two cubic feet sand	0.05
Laying broken stone	0.03
Laying and mixing mortar	0.10
Total per running foot	1.00
Paving per running foot	1.50

The length of canal to be filled from the summit feeder or feeders is, in round numbers, 150,000 feet. In this length are eight pools in Dunlap's Creek, two in Brush Creek, and one in Howard's Creek, and the canal in Brush Creek has a section larger than the standard adopted. The tunnel water-way has less sectional area than the canal section. Supposing the average throughout the line to be the canal section = 441 square feet, there will be required to fill the summit division 66,150,000 cubic feet.

If we suppose while filling the canal the losses by leakage at gates, evaporation, and filtration to equal the amount supposed when estimating for permanent expense, 160 cubic feet per second would be required to supply these losses. The feeder will deliver 360 cubic feet per second. If we neglect the flow of Howard's and Dunlap's Creeks, 200 cubic feet per second of the feeder-delivery will be the available net amount for filling the trunk of the canal. The time required would be somewhat less than four days. This would not seem too long, as some time is required to permit the boats to approach from below.

If artificial ventilation should at any time be necessary, the simplest method would be to utilize the summit-supply of water to provide the power. For the upper level, the Greenbrier feeder is not available for this purpose, except at the great expense necessary to build a longer feeder. This feeder would be available for the lower level through a fall of 12 to 13 feet, but the power would be about two miles from the portal, and this extra length of pipes would be necessary.*

Lorraine made surveys for and located reservoirs on Howard's and Jerrico Creeks, and on Tuckahoe Creek, and presents the following table† of the contents of each:

Reservoir.	Area in acres.	Contents in cubic yards.	Drainage area in sq. miles.	Cubic yards of rain-fall, 37 inches.	40 per cent. for drainage.
Howard's and Jerrico	246	9,276,410	6.750	33,573,870	13,429,548
Tuckahoe	159	7,693,464	9.522	47,361,539	18,944,616

The Howard's and Jerrico reservoir contains 250,463,070 cubic feet, which would supply 581 cubic feet per minute = 36,512 foot-pounds per foot of fall. We can get 60 feet of fall at the west portal, which from this reservoir would give 2,190,720 foot-pounds per minute; 75 per cent. of this would be 1,643,640 foot-pounds per minute, nearly 50 horse-power.

The Tuckahoe reservoir contains 207,723.528 cubic feet, which would supply 480 cubic

* This availability of the Greenbrier feeder is an advantage possessed by the lower level not mentioned heretofore.

† I am indebted to Mr. J. M. Harris, superintendent James River and Kanawha Company, for this table.

feet per minute for 300 days = 30,000 foot-pounds per minute for each foot of fall. The site of this reservoir is now cut up by railroad, but more than one-half the above contents could probably be counted upon—15,000 pounds per minute through a fall of 60 feet would give 900,000 foot-pounds per minute, 75 per cent. of which would be 20½ horse-power nearly. It would not always be necessary to draw from the contents of these reservoirs, as on many days the flow of Howard's Creek would supply all the power necessary. Some of the water from these reservoirs would be lost by evaporation, &c., before arriving at the portal. But the natural drainage pertaining to them will supply much more than double the quantity supposed to be used.

It will be observed that while arranging the tunnel for four lockages each way per hour, the estimate for the water-supply has been made on a basis of three lockages each way per hour. If there be but three lockages on an average, it would probably occur frequently, as the fleets must start promptly on time, that a boat slightly behind time for one fl et would with rapid lockages in the next interval form a fleet of six boats, and those fleets which move the slowest regulate the rate of progress through the tunnel. Then, as now arranged, the maximum lift of lock is 14 feet. Six lockfuls would most probably be sufficient for this lift, as boats cannot be so readily passed as through locks of less lift, and there must be some alternate passages.

If eight lockfuls be really necessary, the amount of water to supply the summit division, the losses being as supposed, will be 356 cubic feet per second, which is less than the delivery of the feeder. We have, besides, the flow of Howard's and Dunlap's Creeks.

If required, the depth of water in the feeder may be made more than 5 feet, thus increasing the delivery. The velocity in the tunnel would be increased. If eight lockfuls be necessary, the amount required east of the summit would be 11,076 cubic feet per minute. Deducting the minimum flow of Dunlap's Creek, the remainder, 10,511 cubic feet per minute, would be the amount to be delivered by the tunnel. The velocity would be 31.1 feet per minute, (= 1,866 feet per hour, say $\frac{4}{11}$ miles = 1,920 feet.) The necessary horse-power for tow-boat would be 44.72 horse-power, an increase of but 0.62 horse power over the amount estimated for.

I would recommend that the lifts of the locks in Dunlap's Creek Valley be changed to decrease the maximum lift. If 8 feet should be adopted throughout the line, the quantity of water required east of the summit, supposing eight lockfuls to be necessary per hour, would be decreased 2,304 cubic feet per minute. The amount to be delivered by the tunnel would be 8,207 cubic feet per minute, and the power necessary for the tow-boat would be 37½ horse.

If a reservoir were constructed on Dunlap's Creek of sufficient capacity with the flow of the creek to supply the losses from evaporation and filtration below the mouth of Brush Creek, the amount to be delivered by the tunnel would be still further reduced by 2,822 cubic feet per minute, and the power necessary for the tow-boat would be only 31½ horse. This reduction of power would materially diminish the consumption of fuel in the tunnel, and to that extent relieve the ventilation, besides decreasing the running expenses and first cost.

The reservoir necessary would not be large. McNeil found the average flow of Dunlap's Creek, from August 7 to September 27, 1826, to be 19 cubic feet per second; and from the 17th of May to June 16, 1827, the average was 94.41 cubic feet per second. The amount required would be less than 50 cubic feet per second. This is a matter to which attention should be directed while the tunnel is being excavated. Lorraine made a survey for a reservoir on Cove Creek, and it is one of those shown on his map of the summit, but I cannot learn that he made an estimate of cost or left any record of its capacity or area of drainage. During the spring, fall, and winter seasons there is no doubt that Dunlap's Creek will provide the necessary supply. These being the times of greatest trade, it may be that no reservoir will be required, and that the power necessary, measured on the chain, will be at all times less than 40 horse. If the commerce of the line should decrease during slack trade to six lockages per hour, the intervals between fleets can be increased to two hours, when the effective power necessary will be 27.3 horse.

In closing this report I would make some remarks on the apparently great difficulties attaching to the construction of the summit tunnel.

A tunnel of the length proposed (nearly eight miles) is no new or experimental matter at all. The Mount Cenis tunnel is nearly as long as this, while the Saint Gothard tunnel through the Alps, now being excavated, will be about 8,000 feet longer. At neither of these tunnels could shafts be found to expedite the construction, while the Alleghany tunnel will have ten or twelve of moderate depth, thus dividing the long tunnel practically into a number of shorter ones. The deepest shaft is 400 feet less depth than the central shaft of the Hoosac tunnel.

The rates of progress at shafts and at headings are assumed at 30 feet per month for the former and 100 feet per month for the latter. The progress at the central shaft of the Hoosac tunnel, as mentioned, was 30.1 feet per month, while the excavation was carried on in the lower half of a shaft 1,028 feet deep, at which insufficient preparations had been made for the proper construction of the tunnel.

Mr. H. D. Whitcomb writes me as follows: "The 370-foot shaft at Great Bend tunnel is the best guide I have to offer for progress in a deep shaft. It was removed by contract to a depth of 70 feet. The remaining 300 feet was sunk in six months. Some of the rock was a very hard sandstone. I think the best progress made was about 70 feet in one month."

I have not the slightest doubt the Alleghany shafts could be sunk at the average rate of 50 feet per month easily. Mr. Whitcomb informs me that the greatest progress he remembers (in heading) at Great Bend was 180 feet per month. "In very hard sandstone in that tunnel we made 80 feet. A fair average would be 125 feet. In the Lewis tunnel, I suppose 65 feet would be a fair average without machinery, *i. e.*, without machine-drills." Subsequently he wrote: "Mr. Talcott says he thinks I over-estimated the average progress at headings, *i. e.*, counting all delays. He says: 'An average would be 100 feet per month. But I will add that the contractor was inexperienced, and I feel sure that another such tunnel would be driven faster.'"

The Great Bend tunnel was, I believe, excavated by hand-drills. The progress at the Hoosac tunnel was about 130 feet at portal headings, and would have been more than 100 feet from the deep shaft if sufficient pumping-machinery had been provided.

At the Mount Cenis tunnel the average monthly progress at headings, from 1864 to 1870, was as follows:

	Feet.		Feet.
1864	148.6	1867	265
1865	168.3	1868	180.4
1866	140.1	1870	223.5

For the entire seven years the average monthly progress was 180 feet at a heading.

The Saint Gothard tunnel through the Alps is the last great enterprise of the kind put in execution, and will be 49,733 feet in length. In 1874 the average monthly progress at a heading was 217.6 feet. For the first four months of 1875, (the last connected account I have seen,) the average daily progress was more than 10 feet, and, in September, 1875, the last report I have found, the progress was 419 feet at one heading and 344 feet at the other.

We have every reason to expect more rapid progress at the Alleghany tunnel than has been assumed.

Attention is particularly invited to the profile of the recommended line. The deepest shaft is about 600 feet. If this be used, there is no doubt whatever that the western heading of Kate's Mountain will be open to the portal in two years. Twenty-five and three-fourths months is the estimated time, assuming progress at shafts at 30 feet per month and 100 feet at headings.

If shaft 7 *bis* be used, Kate's Mountain heading (western) will be open to the portal in less than 20 months.

The eastern heading of Lewis Mountain will be open to the portal in less than 11 months.

At the end of the second year the work will be in the following condition: All shafts will be excavated; the longest headings will be open to the portals; 21,554 feet of tunnel (more than half the entire length) will be excavated, and operations will be carried on at the portals and but 6 shaft-headings. At the end of the fourth year, the entire tunnel will be excavated except about 1,000 feet at Kate's Mountain, both headings of which will be open to the portals. The more the matter is considered, the less do the difficulties appear.

Estimates in detail of the line from Dunlap's Creek to the Greenbrier River, including those for the feeder, accompany this report. The total of this division, inclusive of contingencies, as shown by the recapitulation, is $16,387,757.45.

The estimate for the tunnel includes arching throughout; should any portion require no, or but partial, arching, the amount thus saved will fully cover any increased cost of excavation due to the harder rock. It may be that the excavation at the recess will assume the pointed form. If so, the cost will be somewhat increased at these points, but not materially, as the extra excavation will come out as loose rock. The cost of tunnel-excavation is taken at $5 per cubic yard. I believe this to be a fair price. Shaft-excavation is taken at $10 per cubic yard. This is but one-half the price assigned this excavation in previous estimates. I judge $10 to be sufficient, from the following information kindly furnished me by Mr. Whitcomb, viz:

"The main shafts (two) of the Great Bend tunnel were 170 and 370 feet (about) respectively. The contract-price was $6 per cubic yard. The contractor excavated the shorter shaft, and, say, 90 feet of the deeper; the company then completed the deeper one. The contractor received an allowance on the shorter shaft, bringing the cost up to between $11 and $12. I think the deep shaft cost us between $13 and $14 per cubic yard; size, 8′ × 18′. We had to wagon all machinery 40 miles across a rough country or send it via Greenbrier River in boats. I suppose such a shaft would be done now for $10 per cubic yard."

The greater size of the Alleghany shafts (10′ × 40′) will tend to reduce the price per cubic yard.

Brick arching is estimated at $12 per cubic yard, and the masonry lining below the water-surface at $8 per cubic yard.

In the estimate for dam and lock masonry the cost has been taken at $9 and $10 per cubic yard, respectively, for the purpose of keeping a uniform standard with the New River estimates. This course is also adopted with the Greenbrier division.

As far as known of the summit and Greenbrier, some difficulty may be encountered in getting stone which can be cut easily or readily dressed to shape, and for that reason masonry may cost somewhat more than in the New River division, where unlimited quantities of fine stone abound.

In a large enterprise of this kind the development of resources may be expected which have been hitherto undiscovered or unemployed.

This is most probable with regard to cement, as I understand that fine cement-stone exists at Callahan's, (a short distance westward of Covington.) Proximity to the cement may in part make up for the greater distance from good quarries.

The estimates for masonry, embankment, and excavation for this division, exclusive of the great tunnel, were made by Lieutenant Maguire, with the exception of some changes recently made in the dams. In comparing the estimates of this line with others in the vicinity, it should be remembered that these estimates cover the entire distance from the Greenbrier at the mouth of Howard's Creek to the mouth of Brush Creek. Also, it should be remembered in comparing the entire central water-line with any other that the higher summit of McNeill's is still available, by which the summit may be passed at an elevation of 1,916 feet above tide, with a tunnel 2⅜ miles in length. This is, I believe, with approach-cuts, 50 feet in depth, and of moderate length.

All of which is respectfully submitted.

THOMAS TURTLE,
First Lieut. of Engineers.

Major WILLIAM P. CRAIGHILL,
Corps of Engineers, U. S. A.

RECAPITULATION OF ESTIMATES FOR SUMMIT DIVISION, SURVEY OF 1874.

Total estimate of Brush Creek	$827,787 49
Total estimate of tunnel	12,376,608 29
Total estimate of Howard's Creek	1,251,162 69
Total estimate of feeder-line	444,134 77
Total	14,899,693 24
Contingencies, 10 per cent. of total	1,489,969 32
Grand total	16,389,662 56

REPORT ON GREENBRIER DIVISION, SURVEY OF 1874, BY LIEUTENANT THOMAS TURTLE, CORPS OF ENGINEERS.

BALTIMORE, MD., *July* 24, 1876.

MAJOR: I have the honor to submit the following report on the surveys and estimates for the Greenbrier division of the central water-line:

After the completion of the surveys for the summit division, those for the Greenbrier commenced, Mr. R. H. Talcott being left in charge in the field, and Mr. W. S. Walker taking one of the transits. The surveys included those for a slack-water navigation and for an independent canal from the western approach of the summit tunnel to the west portal of the Great Bend tunnel of the Chesapeake and Ohio Railroad. From this point to the mouth of the Greenbrier River the surveys were made by Mr. Hutton's New River parties, under the immediate charge of Mr. C. R. Boyd.

From the combined notes of these surveys the maps, four in number, which accompany this report have been made. Sheets Nos. 1, 2, and 3 are on a scale of 1 inch to 200 feet, and show the entire valley as covered by our surveys, while sheet No. 4, on a scale of 1 inch to 600 feet, shows the entire Great Bend. In the autumn of 1874, after the completion of the surveys, preliminary estimates for the slack-water system were made, to accompany a report made at that time. The detailed report was made by Mr. R. H. Talcott. Since that time further study has modified the plans so that a new report will be necessary, though free use is made of that made by Mr. Talcott. No report had been made for the independent canal, as the time did not permit the making of estimates. The slack-water system will first receive attention.

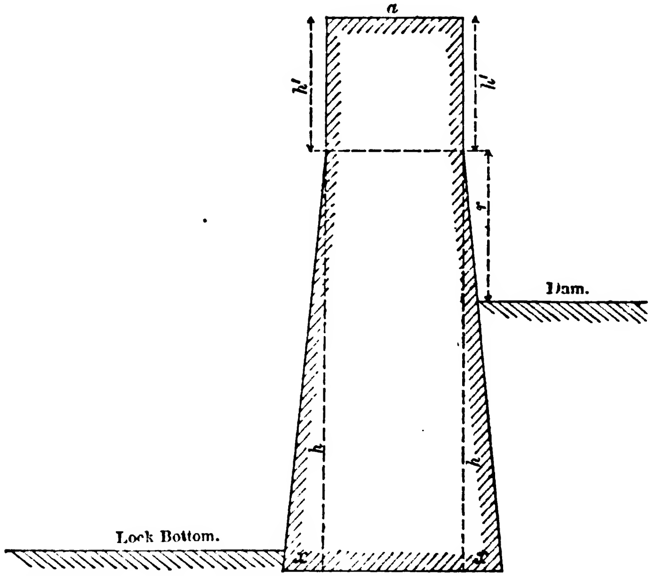
"The survey for the slack-water navigation of the Greenbrier River was begun on the

22d of September, at a point about two miles above the mouth of Howard's Creek, at which it was assumed that the direct tunnel from Brush Creek to the Greenbrier River would debouch, supposing that tunnel to be the one adopted. The transit-line began at station 52 + 11 of an offset line from the direct tunnel, and the levels were started from a bench on a maple about 200 feet to the left of that station, and the elevation assumed was 1,704.24 above mid-tide, that being the mean of two lines of levels run during the previous survey for the summit level."*

In my report for the summit division I recommended the valley of Howard's Creek for the western approach of the summit, and therefore the dams located above dam No. 4 will not be necessary for this line, and no estimates have been made for them.

In the arrangement now recommended the dams have been made as long as can be judiciously done, and the heights of guard-walls and guard-banks have been made to correspond to the lengths of the dams and to the estimated discharge of the stream. For this latter we have no certain data. I am informed by Mr. Talcott that he has personal knowledge of a flood at Graham's Ferry 20 feet above low water, and this flood was not as high by 5 or 6 feet as the highest known, according to the account of the inhabitants near there. A point of highest water was found nearly opposite Caldwell's mill, above Greenbrier bridge, where the rise was about 12 feet. I have taken the former as the safe guide. Herewith is a profile of the Greenbrier River from dam No. 20 (above Graham's Ferry) to the crest of Bacon's Falls. It was supposed that in a flood of 26 feet the irregularities due to the varied slope of the bottom shall disappear, and that the line drawn from the crest of the rapids above dam 21 to the crest of that below Graham's Ferry and above the islands shall represent the slope of the river, and the section be that at this lower point.

I find, by the Humphreys-Abbot formula, the discharge of the stream will be 65,652 cubic feet per second, say 66,000 cubic feet. I think this is a very safe estimate, for the abrupt bends between Graham's Ferry and Bacon's Falls and the islands opposite Rollinsburg must greatly impede the flow of water; accordingly the guard-walls and banks are recommended of such heights as to be above a discharge of this amount at the dams respectively. Mr. Hutton informs me that, in his arrangement of the slack-water system of the New River division, the locks can be used for the passage of boats during the passage of a Greenbrier flood. It is advisable that the Greenbrier may always be navigated when the New River can be, and accordingly the lock-walls, throughout their extent, are carried to the height of the abutment-walls and guard-banks in all cases. The plan of lock adopted by Mr. Hutton for the New River has been taken as the model. The chamber-walls on the river side have been so calculated as to permit the lock to be emptied for repairs with a flood of 40,000 cubic feet per second in the river.



The mode of calculation is a modification of the empirical formula given by Lagrené

* Quoted from Mr. Talcott's report of December 23, 1874.

for calculating the thickness of the chamber-wall of a lock, the inner and outer faces of which shall have the same batter, and is as follows:

r is equal to the rise on the comb of the dam with a discharge of 40,000 cubic feet per second;* h is the height from 1 foot below the bottom of the chamber-wall to the top of this rise; h' is the height of the top of the guard-wall to the top of the rise, and x is the total batter in the height h.

The thickness of a wall of rectangular section which will just retain a column of water of the same height is $\frac{41}{100}h$, the specific gravity of the wall being supposed double that of water. A thickness of one-half h is then an excess of stability. The wall shown in the figure will weigh per unit of length

$$\pi' (a h' + a h + x h),$$

π' being the weight of a unit of volume. The moment is

$$\pi (a h' + a h + x h) \frac{a + 2x}{2}$$

The moment of a wall of rectangular section with height and a thickness of $\frac{1}{2}h$, is

$$\pi' \frac{h^3}{8}.$$

Placing these two moments equal and solving with respect to x we have,

$$\dagger x = \frac{\sqrt{2h^4 + 4a^2hh' + 4a^2h^2 + 9ah'^2} - 3a(2h + h')}{8h}$$

The base of the wall will then be equal to $(a + 2x.)$ The width, a, of the top of the wall has been taken at 5 feet. This break in the face of the wall will indicate for all time the danger-point for the rise in the stream, when the lock is empty and undergoing repairs. The chamber-wall on the land side is in all cases 5 feet on top, with a batter on front and on back of 5 on 1. At most of the dams a study of the character of the excavation will probably permit a decrease of this batter.

The bottom of the wall is taken one foot below the bottom of the chamber. The value of h in the formula will then be equal to r + lift of lock + depth of water on miter-sill + 1, and h' will equal the height of the guard-walls less the rise r.

DETAIL DESCRIPTION OF THE SLACK-WATER SYSTEM.

Dam No. 4, "300 feet long and 23 feet high, and lock No. 4. of 13 feet lift, are located on a solid rock foundation, 1.32 miles below the mouth of Howard's Creek. The lock is on the right, and connected with the hill-side by a guard-bank. On the left, a bluff below the railroad will form a natural abutment. In order to obtain a depth of 7 feet of water from the mouth of Howard's Creek to this dam, a channel will be excavated through the shingle-bar just below the mouth of the creek. An estimate of the cost of this channel is included in that of the dam."

The amount of the excavation required for the lock is very large, (42,499 cubic yards.) It is probable that this amount may be materially decreased, if the location of the dam can be moved up stream. The bend in the stream a short distance below the lock makes a large excavation necessary to provide a proper exit from, and approach to, the tail of the lock. This, and all other questions of location suggested in this report, can be readily determined during the progress of the work. The railroad at this point is out of danger.

"About 200 feet below the dam the railroad crosses the river on an iron undergrade bridge of four spans. The bottom chord of the bridge is only 20 feet above the surface of the pool made by dam No. 5. One span of this bridge will have to be raised, in order to give sufficient height for the chimneys of steamers, and made a through bridge."

Dam No. 5, 450 feet long and 20 feet high, and lock No. 5, of 9 feet lift, are located "on solid rock foundation, just above Clay's mill-dam, and 3.01 miles below dam No. 4. The lock is on the right, and connected with the railroad by a guard-bank. On the left, an abutment of masonry and a guard-bank will also be required."

The railroad is only 8 feet above the comb of the dam, and an estimate is made for relocating it higher on the hill-side.

Dam No. 6, 410 feet long and 21 feet high, and lock No. 6, 10 feet lift, "are located on a ledge of sandstone 1.13 miles below dam No. 5. The lock is on the right, and connected with the railroad by a guard-bank. A rock bluff on the left forms a natural

* Estimated by Francis's formula, $Q = 3.33 \,.\, l \,.\, r^{\frac{3}{2}}$, in which Q is the discharge in cubic feet per second, in this instance is 40,000 feet; l is the length of the dam.

† If we make $h' = 0$, the formula becomes

$$x = \frac{\sqrt{a^2 + 2h^2} - 3a}{4}$$

which is the empirical formula given by Lagrené, the column of water and the wall being of equal height.

abutment. The railroad at this point is only 10 feet above the comb of dam, and will either have to be raised or protected for a distance of 6,000 feet by an embankment. A dike along the river would protect the low grounds and railroad."

An estimate for raising the railroad is included in the estimate for the dam. An alternative to the construction of this dam suggests itself on an examination of the map, viz:

To leave dam No. 5 by a guard-lock, and by means of a canal and 2 locks through the flats at Ronceverte, to reach the river below the mill at the elevation necessary to enter the pool of dam No. 7. An estimate of this alternate canal has been prepared for comparison, with the following results:

Dam No. 5, first estimate	$62,689 30
Lock No. 5, first estimate	113,935 68
Dam No. 6, first estimate	62,668 40
Lock No. 6, first estimate	123,544 88
Total	362,838 26

The total estimate for the alternate canal is $380,946.29, being an excess of $18,108.03 over the first estimate. The alternate estimate is but approximate, as the surveys do not supply complete data, for the alternate was not contemplated when the survey was made. I believe that I have allowed excessive quantities for this alternate line, and that an actual survey will show that the cost will be less than estimated. But even if the estimated cost should be not too great, the contingencies and damages would be less for the canal than for the dam and the lift-locks. The alternate estimates were for a canal 120 feet wide on the bottom, with side slopes 1 on 2, and the walls of the lower lock were supposed 20 feet above the comb of dam No. 7.

The cutting for the upper canal was supposed to average 6 feet deep throughout, and that for the lower canal 4 feet deep. Of course the location of the lock is but conjectural, and can only be made after survey. I recommend the alternate canal, subject to future survey, which should also provide more complete data for the change of railroad necessary with dam No. 6.

Dam No. 7, 350 feet long and 18 feet high, and lock No. 7, 7 feet lift, "are located on a solid rock foundation, 1.53 miles below dam 6. The lock is on the left bank, and will be connected with the high ground by a guard-bank; on the right a rock bluff under the railroad will give a natural abutment."

An estimate for the change of railroad is included in the estimate of the dam.

I think it would be well, during the construction of the line, to examine this site with the view of locating the lock on the right bank, whereby the excavation for the lock might perhaps be much reduced. The bend in the river below is not advantageous for the lower approach as now arranged.

Dam No. 8, 350 feet long and 18 feet high, and lock No. 8, of 9 feet lift, "are located on a sandstone ledge, covered with shingle on the right bank, but well defined on the left, and 1.32 miles below dam No. 7. The lock is on the right, and connected with the railroad by a guard-bank. On the left an abutment of masonry and a short guard-bank will connect the dam with the hill-side. The railroad is here 17 feet above the comb of dam, and out of danger."

Dam No. 9, 320 feet long and 6 feet high, and lock No. 9, of 13 feet lift, "are located on a sandstone ledge, underlying red shale, 1.94 miles below dam No. 8. The lock is on the right, and connected with the high ground by a high bank. On the left a bluff of red shale will require a light masonry abutment."

This location is not the most advantageous for the approaches to the lock, and I would suggest further examination in this vicinity for an improved location.

Dam No. 10, 435 feet long and 20 feet high, and lock No. 10, of 13 feet lift, "are located on a limestone ledge, 2.14 miles below dam No. 9. The lock is on the left, and connected with the railroad by a guard-bank. On the right a limestone cliff forms a natural abutment. Between this dam and dam No. 9 the railroad crosses the river on an iron undergrade bridge, the bottom chord of which is only 14.5 feet above the surface of the pool, and the rail is only 34 feet above it. One span of this bridge will have to be raised and made a through bridge, which will give 30 feet clear above the surface of pool. Should more height be required, it will be necessary to change the grade in a tunnel which is not more than 400 feet from the abutment of bridge. The railroad at the dam is 15 feet above the comb, and out of danger."

Dam No. 11, 350 feet long and 22 feet high, and lock No. 11, 11 feet lift, "are located on a limestone ledge in Davis's Falls, and 1.45 miles below dam No. 10. The lock is located on the right, and connected with the high ground by a guard-bank."

Dam No. 12, 350 feet long and 24 feet high, and lock No. 12, of 13 feet lift, "are located on a limestone ledge, 0.97 mile below dam No. 11. The lock is on the right, and connected with the high ground by a guard-bank. On the left a limestone bluff under the railroad forms a natural abutment. The railroad is here 28 feet above comb of dam, and is out of danger." The location of this dam is disadvantageous for the ap-

proach to the lock, and in general it may be said that such must always be the case at a bend, unless the bend be very slight. The boats, when the water is up, must enter the lock parallel to the thread of the current. The vicinity of this site should be further examined, or it may be that an alternate canal from dam No. 11 may render the construction of this dam (No. 12) unnecessary.

An estimate of this alternate canal has been made. The comparison of the two sets of estimates gives the following results:

Dam No. 11, first estimate	$43,310 65
Lock No. 11, first estimate	125,819 18
Dam No. 12, first estimate	45,075 80
Lock No. 12, first estimate	152,456 98
Total, first estimate	366,662 61
Alternate estimate	337,449 64
Difference in favor of alternate	29,212 97

This alternate is shown on sheet No. 1, and on the cross-sections of the canal-survey. I recommend this alternate, subject to an examination of the lock-sites and the character of the stream in their vicinity.

Dam No. 13, 320 feet long and 20 feet high, and lock No. 13, of 10 feet lift, "are located on a solid limestone ledge, 1.56 miles below dam No. 12. The lock is on the right, and connected with the hill-side by a short embankment. On the left an abutment of masonry will connect the dam with the railroad, which is only 13 feet above comb of dam." An estimate for the change of railroad is included. I would suggest a re-examination of this site to decrease the great amount of excavation necessary for the lock. It may be that the location of the lock on the left bank, or the location of the dam a short distance down stream, may fulfill this object.

Dam No. 14, 310 feet long and 26 feet high, and lock No. 14, of 12 feet lift, "are located on a limestone ledge, 1.13 miles below dam No. 13. The lock is on the right, and connects immediately with the hill-side. On the left a masonry abutment will connect the dam with the railroad, which at this point is only 13 feet above the comb of dam." An estimate for the change of the railroad is included in the estimate for the dam. "Below this dam there is quite a number of large bowlders, which will have to be removed in order to make the channel of sufficient depth and width. This work is included in the estimate." The excavation for this lock is quite great. I should anticipate that a location some 1,200 feet up stream would be an improvement in this particular, the lock being placed upon the left bank.

Dam No. 15, 320 feet long and 20 feet high, and lock No. 15, of 10 feet lift, "are located on a ledge of limestone, 1.04 miles below dam No. 14. The lock is on the right, and connected with the high ground by a short embankment. On the left an abutment of masonry will connect the dam with the railroad." An estimate for the change in the railroad is included in the estimate of the dam. The bend of the stream at this point makes it a disadvantageous location for the lock. I would suggest an examination of a site about 1,000 feet up stream; or it may be that a short canal may be located from dam 14, which will render dam 15 unnecessary, especially if the location of dam 16 be changed as mentioned in the following description.

Dam No. 16, 300 feet long and 22 feet high, and lock No. 16, of 9 feet lift, "are located on a smooth sandstone ledge just above Alderson depot, and 1.13 miles below dam No. 15. The lock is on the right, and requires a guard-bank 2,650 feet long to connect it with the high ground, and protect the bottom lands below the dam. On the left an abutment will connect the dam with the railroad, which is only 12 feet above the comb of dam, and ought to be raised to be out of danger. An estimate for the change of the railroad is included in the estimate for the dam. In order to reduce the height of the next dam below, a channel will have to be excavated through the shingle-bar just below the town of Alderson. An estimate for this work is included." As an alternative to this dam, which will also avoid the construction of dam No. 17, the following suggests itself, viz. to build a dam about 2,700 feet up stream, designated dam 16 A on the map, (sheet No. 2,) then, leaving this dam by a guard-lock on the right bank, to locate a canal through the flats, and finally, as indicated on the map, to enter the pool of dam No. 18 below Muddy Creek. An estimate of this alternate has been made, with the following result:

Dam No. 16, first estimate	$66,922 65
Lock No. 16, first estimate	131,211 18
Dam No. 17, first estimate	88,115 75
Lock No. 17, first estimate	126,380 28
Total, first estimate	412,629 86
Alternate estimate	444,086 69
Difference against alternate	31,456 83

But the contingencies will be less in the alternate, the land-damages will be very much less, as well as prospective damages from floods, and the long guard-banks of dams 16 and 17 will be avoided.

The alternate canal, as estimated for, is 120 feet wide on the bottom throughout. I recommend the adoption of the alternate line, subject to an examination for the site of dam 16 A and for the location of the locks on the island at Muddy Creek. Boring should also be made in the flats in order to assure the excavation of the canal in loose material. The following may be found advantageous. To build dam 16 A somewhat higher than estimated, which would decrease the depth of cutting through the flat and perhaps render the canal from dam No. 14 expedient, thus avoiding the construction of dam 15.

Dam No. 17, 450 feet long and 23 feet high, and lock 17, 10 feet lift, "are located on a sandstone ledge below the mouth of Muddy Creek, 1.59 miles below dam No. 16. The lock is on the left, and requires a very long guard-bank or dike," and that the railroad be protected from floods. An estimate for the change of the railroad is included in the estimate for the dam. "On the right an abutment of masonry and a guard-bank connect the dam with the high ground. Below this dam the channel will have to be cleared of some shingle and bowlders in order to be safe. This work is included in the estimate."

Dam No. 18, 450 feet long and 20 feet high, and lock No. 18, of 11 feet lift, "are located on solid rock foundation, 2.56 miles below dam No. 17. The lock is on the left, and will be connected with the dam above by a guard-bank. The railroad must be raised for about 6,000 feet up from the dam." An estimate for this change is included in the estimate for the dam. On the right a masonry abutment will connect the dam with the hill-side.

Dam No. 19, 390 feet long and 19 feet high, and lock No. 19, of 9 feet lift, "are located on a ledge of sandstone, 2.43 miles below dam No. 18, and about one mile above Haines's Ferry. The lock is on the left, and is connected with the railroad by a guard-bank. The railroad must be raised for about 4,000 feet for protection. An estimate for this is included in the estimate for the dam."

Dam No. 20, 450 feet long and 18 feet high, and lock No. 20, of 8.5 lift, "are located on a ledge of sandstone, 3.56 miles below dam No. 19. The lock is on the left, and connected with the high ground by a guard-bank." It would be better, on account of the bend immediately below, if the location were changed a little up-stream.

Dam No. 21, 420 feet long and 18 feet high, and lock No. 21, of 8.5 feet lift, "are located on a sandstone ledge, one-fourth of a mile above Graham's Ferry and 1.75 miles below dam No. 20. The lock is on the left, and connected with the high ground by a guard-bank. On the right an abutment of masonry and a short guard-bank connect the dam with the hill-side. Below this dam there are some bowlders and shingle which will have to be removed to make the channel of sufficient width and depth. About one-fourth of a mile below dam No. 21 the railroad crosses the river on an iron through bridge of four spans, of 128 feet each. The bottom chord of the bridge is only 21 feet above the surface of the pool." If the railroad interferes with the navigation it may be raised some distance each side of the bridge.

Dam No. 22, 557 feet long and 17 feet high, and lock No. 22, of 8 feet lift, "are located on a ledge of sandstone, at the head of Bacon's Falls, or the Great Falls of the Greenbrier, and 4.12 miles below dam No. 21. The lock is on the left, and connected with the bluff. On the right a perpendicular bluff of sandstone forms a natural abutment. At this point a canal has been located, which runs back of Bacon's mill, and locks down by lock No. 23, of 11 feet lift, into the pool formed by dam No. 23. This canal is calculated of sufficient width for two large boats to pass each other."

Dam No. 23, 400 feet long and 17 feet high, and lock 24, of 10 feet lift, "are located on a ledge of sandstone at the head of the Little Falls of the Greenbrier, and 0.99 mile below dam No. 22. The lock is on the left, and connected with the high ground by a guard-bank. On the right a cliff of shale will have to be protected by a masonry abutment. Below this dam there are quite a number of bowlders of moderate size which will have to be removed."

Dam No. 24, 446 feet long and 22 feet high, and lock No. 25, of 11 feet lift, "are located on a ledge of sandstone, one-fourth mile above Carden's White Sulphur Springs, and 0.91 mile below dam No. 23. The lock is on the left, and is connected with the high ground by a guard-bank. At this dam, an island above, and one also below, will have to be excavated in order to make a channel of sufficient width." An alternate line from above dam No. 22 is suggested, in detail, as follows: Build a dam, designated on the map (Sheet No. 3) dam 22 A, (foundation solid rock and length of dam 538 feet,) with a lift of 7 feet, locking into the pool of a dam to be built near where the crossing was made at Station 1876 + 22. This dam would be about 22 feet high. In reply to a request for information, Mr. Talcott writes me as follows: "The rock ledge below Bacon's Falls where line crosses to left bank, is not lower than about 1,462, if as low, for the fall from foot of Bacon's Falls to this point is very slight. A 30-foot dam could be built at this point and be very secure, for there are natural rock-abutments on both sides of the river. You would flood the present

site of Bacon's mill, but as the water-power would be taken away, that would make little difference in the land-damage." Leaving this dam by a guard-lock on the left bank, a canal may be located through the flats below, until the line again enters the river below dam No. 25. The outline of these flats may be seen by referring to Sheet No. 4. It is seen (Sheet No. 3) that the line enters the river at 4 feet less elevation than the bottom of the lock at dam No. 24, thus permitting the lowering of No. 25, and decreasing the lift of lock 26 by that amount.

An estimate of this alternate line has been made for comparison, with the following result:

Dam No. 22, first estimate	$43,363 46
Lock No. 22, first estimate	108,729 18
Canal round Bacon's Falls	33,312 40
Lock No. 23	105,793 18
Dam No. 23, first estimate	46,994 60
Lock No. 24, first estimate	125,531 48
Dam No. 24, first estimate	71,307 63
Lock No. 25, first estimate	115,561 28
Dam No. 25, first estimate	55,992 48
Lock No. 26, first estimate	120,319 38
Total	826,690 07
Alternate estimate	753,715 19
Difference in favor of alternate	62,974 88

The estimate for this alternate is but approximate, as, the line not being contemplated in the survey, our data are not complete. I have every confidence that the quantities are full and the estimate is sufficiently great. The canal around Bacon's Falls is necessarily an awkward arrangement, from the little available space and the necessary lengths of the locks. Dam No. 23 is a disadvantageous location from the bend in the stream. Its location shou d be changed, or the excavation for lock 24 should be greater than estimated for. The land-damage for dam No. 24 would be great, or for the guard-bank there should be substituted a dike 4,800 feet long, connecting this dam with the one above, in which case the estimate for dam No. 24 would be increased. I decidedly recommend the alternate line. This alternate being adopted,

Dam No. 25 will be 426 feet long and 16 feet high, and lock at same (No. 26) will be of 7 feet lift. The site is on a ledge "of sandstone 0.96 mile below dam No. 24. The lock is on the left, and connected with the high ground by a guard-bank. On the right an abutment of masonry connects the dam with the hill-side."

Dam No. 26, 350 feet long and 23 feet high, and lock No. 27, of 11 feet lift, "are located on a sandstone ledge 0.92 mile below dam 25. The lock is on the left, and is estimated for as connected with the hill-side by a guard-bank, though it might be advisable to connect it with the dam above by a dike along the river, which would increase the estimate for guard-bank." This site is disadvantageous for the location of the lock. and if a dam be built near here I would suggest an examination for a site 1,000 to 1,400 feet below, when it might be advisable to increase the lift of the lock and decrease the height of dam No. 27 and the lift of lock 28. As an alternate to the construction of this dam the following is feasible, viz: Leave dam No. 25 by a guard-lock on the left bank, and then by a canal and locks to enter the river below dam No. 26, as indicated on the map, (Sheet No. 3.) This alternate will enter the river at 2 feet less elevation than the bottom of lock 27. An estimate for comparison gives the following:

Dam No. 25	$40,576 83
Lock No. 26	106,198 88
Dam No. 26, first estimate	50,403 55
Lock No. 27, first estimate	136,260 58
Dam No. 27, first estimate	42,867 80
Lock No. 28, first estimate	123,083 28
Total	499,390 92
Alternate estimate	455,441 95
Difference in favor of alternate	43,948 97

This estimate for the alternate is but approximate, but I am quite confident the quantities assumed are sufficiently full. I recommend the alternate line, subject to examination. If this alternate be adopted—

Dam No. 27 will be 340 feet long and 20 feet high, and lock No. 28 will be 8 feet lift. The site is on a sandstone ledge 1.55 miles below dam No. 26. The lock is on the right, and connected with the high ground by a guard-bank. On the left a bluff of shale

will need some masonry to protect it. A low dike may be necessary to decrease land-damages by protecting the low grounds above. (See Sheet No. 4.)

Dam No. 28, 360 feet long and 22 feet high, and lock No. 29, of 10 feet lift, "are located on a sandstone ledge 1.14 miles below dam 27. The lock is on the left, and connected with the hill-side by a guard-bank. On the right an abutment of masonry will connect the dam with the hill-side."

As an alternate to the construction of this dam, the following may be found available, viz: Build a dam as an alternate to dam 27 (designated on Sheet No. 3 as dam 27 A) near station 2,152 of the transit-line. Then leave this dam by a guard-lock on the left bank, and by a canal and locks enter the river below dam No. 28. By this line the river may probably be entered at 6 feet less elevation than the bottom of lock No. 29, thus lowering the comb of dam 29.

An estimate made for comparison gives the following:

Dam No. 27, as recommended	$35,411 55
Lock No. 28, as recommended	102,135 [illegible]
Dam No. 28, first estimate	53,923 45
Lock No. 29, first estimate	116,921 [illegible]
Dam No. 29, first estimate	42,400 75
Lock No. 30, first estimate	112,172 [illegible]
Total	462,965 39
Alternate estimate	486,624 62
Difference against alternate	23,659 23

The alternate estimate is only approximate, but I believe the quantities to be very full, and, there being one less dam to build, the contingencies will be less. I recommend this alternate line, subject to an examination. If this be adopted,

Dam No. 29, 420 feet long, will be 15 feet high, and lock No. 30 will be 4 feet lift. The site is on a sandstone ledge, 1.5 miles below dam No. 28. The lock is on the right, and connected with the high ground by a guard-bank. On the left an abutment of masonry connects the dam with the steep hill-side.

Dam No. 30, 340 feet long and 22 feet high, and lock No. 31, of 11 feet lift, "are located on a sandstone ledge, 1.49 miles below dam No. 29. The lock is on the left, and connected with the hill-side by a short embankment. On the right an abutment of masonry will connect the dam with the hill-side. Below this dam there are some very large bowlders which will have to be removed to give sufficient water-way. This work is included in the estimate." The bend in the stream at this point renders this site a very disadvantageous one. I would suggest that the location be made lower down—the position designated dam No. 30 A, on sheet No. 3.

The notes as copied on the map indicate the probability that rock-foundation may be found anywhere in the vicinity. It may also be found that the elevation of the lower level may be decreased, and that the lift of the locks Nos. 30 and 31 may, with advantage, be more nearly equalized by locating dam 29 farther down stream, perhaps about opposite station 54 of the line from the portal of the Great Bend tunnel.

Dam No. 31, 326 feet long and 16 feet high, and lock No. 32, of 10 feet lift, "are located on a ledge of sandstone, 2.67 miles below dam No. 30. The lock is on the right, and connected with the high ground by a short guard-bank. On the left a sand-bluff forms a natural abutment."

Dam No. 32, 465 feet long and 14 feet high, and lock No. 33, of 2.2 feet lift, "are located on a sandstone ledge, 1.51 miles below dam No. 31. The lock is on the right, and connected with the railroad by an abutment of masonry, and a guard-bank will connect the dam with the high ground."

This dam is the last on the Greenbrier River, and connects the slack-water system on that river with that of New River.

At this point there exists a difference of recorded elevations between the notes of the surveys of the Greenbrier division and those of the New River. This difference is probably owing to a difference in the elevations assumed at the initial benches.

The elevations in the Greenbrier survey are carried from the initial bench of the summit division at the mouth of Fork Run. This difference of recorded elevation is noted, Mr. Hutton tells me, in his report on the New River division.

In the project of 1872 for the slack-water navigation of the Greenbrier River, it was proposed to tunnel the Great Bend. My opinion is opposed to this project. It must exceed in cost the slack-water round the bend by a large amount. No estimate of it is submitted.

The saving of distance does not necessarily produce a saving of time, for the rate of motion must be less within the tunnel than in the open river. The up-stream approach would be difficult. Guard-locks would there be necessary, and the boats could not enter them across a current of even moderate velocity, and could not leave them in the

same circumstances without serious danger of accident from the leverage upon the boat from the down-stream pressure of the current. Then the accumulated lockage at the down-stream end of the tunnel (92 feet) would necessitate a flight of 8 or 10 locks at this point. The demands of the line would require that the flight be double. The cost of such a flight in the narrow creek-bed would be exceedingly great, and the approach to the lowest locks must necessarily be difficult, as the objection to leaving or entering the locks across the current would apply similarly as at the upper portal.

The total distance from the mouth of Howard's Creek to dam No. 42 is 48.32 miles, and the total lockage 301.2 feet. A detailed estimate of the cost accompanies this report. The recapitulated estimate of the line as recommended is as follows:

Dam No. 4	$59,971 95
Lock No. 4	164,730 98
Alternate canal at Ronceverte, to avoid—	
Dam No. 6	380,946 29
Dam No. 7	67,437 50
Lock No. 7	114,523 48
Dam No. 8	41,753 40
Lock No. 8	126,537 38
Dam No. 9	54,743 70
Lock No. 9	157,355 08
Dam No. 10	46,742 30
Lock No. 10	129,231 28
Alternate canal from dam No. 11, to avoid—	
Dam No. 12	337,449 64
Dam No. 13	41,730 80
Lock No. 13	195,360 98
Dam No. 14	80,946 00
Lock No. 14	156,240 58
Dam No. 15	53,849 80
Lock No. 15	141,454 08
Alternate canal, to avoid—	
Dams Nos. 16 and 17	444,086 69
Dam No. 18	84,729 10
Lock No. 18	132,015 58
Dam No. 19	55,634 75
Lock No. 19	129,028 18
Dam No. 20	47,235 00
Lock No. 20	106,118 38
Dam No. 21	45,477 90
Lock No. 21	111,761 08
Alternate, to avoid the construction of dam No. 22, locks Nos. 22 and 23, canal round Bacon's Falls, dams Nos. 23 and 24, and locks Nos. 24 and 25.	753,715 19
Alternate canal from dam No. 25, to avoid dam No. 26	455,441 95
Alternate dam No. 27 and canal, to avoid dam No. 28	486,624 82
Dam No. 30	58,832 70
Lock No. 31	134,174 98
Dam No. 31	26,104 40
Lock No. 32	148,226 88
Dam No. 32	29,270 40
Lock No. 33	83,507 68
Total	5,682,990 93
Contingencies, 10 per cent	568,299 09
	6,251,290 02

Total estimate of the slack-water system recommended for this division, including 10 per cent. contingencies, is $6,251,290.02. Attention is invited to the remarks made in the report of the summit division, relative to the cost of lock and dam masonry.

The estimates for the dams have been made on the basis adopted by Mr. Hutton in the New River division. The classification of the excavation for the locks and dams is the same as adopted by Mr. Talcott in his report of 1874.

The Chesapeake and Ohio Railroad maps were used to assist in the plotting of the railroad and of the bank of the stream not covered by our surveys.

The estimates were made by Mr. J. L. Seager.

Table showing length and height of dams, height of guard-walls, and amount of water each dam will discharge before the flood will reach the top of the guard-wall.

Number of dam.	Length in feet.	Height in feet.	Height of guard-walls and banks.	Will discharge cubic feet per second—	Remarks.
4	360	23	17	70,000	
5	450	20	14	78,400	
6	410	21	14.5	75,300	
7	350	18	16	74,500	
8	330	18	17	75,200	
9	320	26	17	74,600	
10	435	20	14	75,800	
11	350	22	16	74,500	
12	320	24	17	74,600	
13	320	20	17	74,600	
14	310	26	17	72,300	
15	320	23	17	74,600	
16A	375	22	16	79,900	Estimated height and length.
16	300	22	17	70,000	
17	450	23	14	78,400	
18	450	20	14	78,400	
19	390	19	15	75,400	
20	450	18	14	78,400	
21	420	18	14	73,600	
22A	530	15	13	82,700	
22	557	17	13	86,900	
23A	400	22	14	69,700	Estimated length.
23	400	17	14	69,700	
24	446	22	14	77,700	
25	456	16	14	79,500	
26	350	23	16	74,500	
27	340	20	16	72,400	
27A	400	27	16	69,700	Estimated length and height.
28	360	22	16	76,700	
29	420	15	14	77,000	
30	340	22	16	72,400	
31	326	16	16	69,400	
32	465	14	14	81,100	

GREENBRIER DIVISION—CANAL LINE.

A survey was made for an independent canal simultaneously with the survey for a slack-water navigation.

The following notes descriptive of the line of the canal-survey, taken by Mr. Talcott in the field, are copied from his note-book:

"The line for the canal was begun at the point on Greenbrier River, above the mouth of Howard's Creek, at which the northern tunnel-line would debouch should that be chosen. It crossed the river immediately, and can be crossed over either on aqueduct or slack-water, there being a good rock-ledge immediately at the point at which the line crossed. It then was run down on the right of the river, over the bottoms, until it crossed the James River and Kanawha turnpike, just below which point the hill closes into the river. Above this point the line was connected with the line from southern tunnel, it being thought best to run on the feeder-line and cross above the bridge, where a good rock-bluff forms a natural abutment, and a ledge of rock making on from the left bank would give a good foundation for piers.*

"A connection was also made near the mouth of Howard's Creek. From the point above named, or say station 109 of canal-line, down to station 180 the ground as a general thing is rough, steep, and formed of bowlders from the hill-side. The work here might be estimated as about one-half solid rock and one-half loose rock. At about the above-named station the line was crossed to the left bank and notes taken for either an aqueduct or slack-water, there being fine ledges for foundation. A crossing was also run below the railroad bridge, where it would be necessary to cross by aqueduct, as slack-water would raise the river so much as to endanger the railroad bridge. It

* At the time the survey was begun I was under the impression that the canal-line should at once cross to the right bank of the Greenbrier River, and that the elevation of the summit would be 1,720 feet above the tide. This being assumed, I thought of crossing the Greenbrier on an aqueduct after tunneling through the crest where the feeder-tunnel for the summit is located. These views are abandoned in the recommended location.—T. T.

will be necessary to cross the railroad at this point, as here it takes the right bank and occupies the only ground that could be used for canal-line. From the bridge down for about a mile there is pretty good ground, the bottom being narrow, but wide enough for canal. Thence down the river to a bluff about opposite Clay's Mill the ground is steep and rough and of sandstone, either in ledge or bowlders. It would be safe to take three-quarters solid rock and the rest loose rock in the cutting required here.

"At the bluff opposite Clay's Mill the best plan would be to tunnel for (say) 500 feet, as any other method would involve heavy cutting in limestone or a high retaining-wall, which would be exposed to the strength of the current in times of high water. After passing the bluff the ground improves, and the bottom is wide enough for the canal for about 2 miles, when the bluffs close in again and render a crossing to the right bank advisable. This crossing is at about station 495, and is located on a good ledge of rock; but, owing to the bank being low on both sides, if an aqueduct should be adopted, it might be well to run a little farther down on the left bank before crossing, so as to get a better height for the piers.

"From the crossing to the east portal of Second Creek Tunnel, Chesapeake and Ohio Railroad, the ground is open and a narrow bottom, very good for the canal. At this point the bluff comes in again on the right, and for a half a mile the work would be very expensive if the line was kept on the river; so that, in order to save distance and probably some expense, a tunnel-line was run across the neck, making about 2,800 feet of tunnel, and debouching on a narrow bottom on the river, saving about one mile and three quarters in distance. All of the tunnel will be limestone, which in the railroad tunnel worked well and stands perfectly. After running a short distance in the bottom the bluffs close in on the river again, and for three-fourths of a mile and more the work would be very expensive if kept out on the bluff. A sharp bend in the river below brings the bottom again on the line; but I think that, on a full examination in the office, a tunnel through this spur will be found cheaper and safer than a canal on the bluff, and save about three-fourths of a mile in distance. All of this bluff and spur are limestone. After running in the bend above mentioned, a good bottom-land is struck, which lasts for about a mile, until 'Sinking Creek' is reached. Here the bluff comes down to the river again, and is very steep for about a quarter of a mile. A short tunnel may be found advisable here, or else a sort of gallery. The rock is limestone.

"After passing this bluff the ground opens again and is pretty good for about a mile, when the bluff closes in again. Along here the line was run very high, in hopes of saving cutting by being above some of the bluffs, and also in order to save work below where the flats are high. The rock here is still limestone. After passing these bluffs the ground opens and is pretty good, though rolling for some distance.

About station 900 the rock changes to sandstone, and is almost all in bowlders, though some ledges come down to the river, and limestone makes its appearance at times. Along here, in most cases, the line was run too high, but the cross-sections will give the ground on which it will be best to put the canal, it being impossible to judge accurately what grade would be best until the line was run through. The excavation, all the way down to station 1030, can be taken, as a large proportion is through bowlders, which, in most cases, are so large as to be classed as solid rock, so that at least 75 per cent. of the excavation will be solid rock and the remainder loose rock and earth, the latter in small proportion. At station 1030, or about 1 mile above Alderson's station, the bluffs recede from the river, and the bottoms are very favorable for canal.

"At station 1063 a crossing was made to the left bank, so as to take the benefit of the bottom-lands on that side, where they are much more extensive than on the right, and a line was run and cross-section taken, the above station being equal to 0 of that line. The crossing was on solid rock and was for slack-water. Should it be thought best to cross on an aqueduct, it would be better to go about a mile and a half farther down the river, where good rock-ledges can be found. There is a good ledge in the pool just below Alderson's and above Hill's store, on the right bank, at which an aqueduct could be put. The slack-water crossing was made at the point named, as in order to get across below it would have been necessary to build long dikes to protect the low grounds from overflow, whereas at this point a dike about 3,000 feet long will be all that is necessary to protect the right bank, and on the left there is nothing to overflow. The line was continued on the right bank and all the necessary cross-sections taken, but the ground in many places is of such a character as to render a canal very expensive. From Muddy Creek down for about 2½ miles, with few exceptions, the bluffs are close to the river. The rock, in most cases, is a shaly limestone, and would be easy of excavation. Just below the mouth of Griffith's Creek the bluffs are highest and are of laminated stone, which would stand very well in cuts, but I fear would not be good for tunneling. The river is not wide enough to encroach on it much without danger, so that the canal could not be built out into it.

"Just at the point where Wolf Creek Mountain comes down to the river, on the left bank, the ground opens on the right, and is favorable for canal for about three-fourths

of a mile, when it is rough and rolling again for about the same distance, and then becomes very steep. The rock is a bastard limestone and some pure limestone, not very hard to excavate. At about station 1420, the ground on right bank opens again, and becomes very favorable, being river-bottoms for about two miles. The line on the left was run down the railroad, and cross-sections taken all the way to the river. The ground to station 240 is very favorable, but at this point Wolf Creek Mountain comes down to the river, and for about 3,000 feet the ground is rough and precipitous in some places. At this point the railroad runs close to the river, and the country road just above it, so that there is no room for a canal without throwing the railroad into tunnel, and, it may be, tunneling for canal for a short distance. Cross-sections have been taken of this point to show accurately what will be required, but if the line on the left bank is adopted, the best plan will be to pass this point by slack-water, and for that purpose a dam was located at the upper end of Riff's low grounds, and the necessary notes taken to determine the cost of such a work. From this point down to station 335 the line is cross-sectioned, and at that place a dam is located to cross the canal over to the right bank again, in order to take advantage of the low grounds on that side; for on the left the cliffs come down to the river, and for about two miles the work for canal would be very expensive and require a complete change in the location of the railroad, which cuts along on the bluffs for a short distance, and then runs for a mile over some islands, and, cutting through the point of the bluffs again, emerges on the river-bottom. On the right, after passing the low grounds above mentioned, the bluffs again close down on the river, and make it very expensive ground to cut a canal through. This ground holds for about 2 miles, with some low flats, but as a general thing it is very bad for the work required. Just above Graham's Ferry the ground opens again, and from that point to the Great Bend tunnel there is no great difficulty in getting ground that will suit without very heavy excavation. On the left bank, after passing the point on which the railroad emerges into the open ground again after passing over the islands, the ground is very favorable, and continues so as far as about half a mile below Graham's Ferry, when it becomes steep and rocky for about 1 mile, but not so bad as the ground above Graham's Ferry on the right bank. At Rollinsburg, opposite Talcott station, Chesapeake and Ohio Railroad, the ground opens again, and is very flat and low all the way down to opposite the mouth of the proposed tunnel, and would give a much better approach to the tunnel than can be gotten on the right bank. The proposed tunnel-line is more to the left than would have been necessary but for the railroad, but it can be brought into open cutting in a low place in the ground, and then a short tunnel through a spur below will bring it into the open valley."

With the foregoing, and the notes of the survey as a basis, the location of the canal was made. As it was so soon found necessary to change to the left bank, the project of crossing to the right bank from the Howard's Creek approach was abandoned, and the location of canal-dam No. 1 was chosen to form a slack-water pool, into which the Howard's Creek line debouched. There is no room on the left bank for a canal to this point. The canal leaves this pool by a guard-lock on the left bank and passes through the railroad embankment immediately below, the railroad being carried over by an overgrade truss.

The proximity of this dam to the point where the canal must pass under the railroad makes the location somewhat awkward.

There will be no space for the boats to pass each other from the head of the lock to the lower side of the railroad-embankment, and the bend prevents the steersmen of the ascending and descending boats to note each other's approach. I would recommend that the dam be built farther up stream, so there may be a passing-place immediately below the lock, the location to be made during the construction of the line. This would become imperative if the locks on the line should be doubled in the future.

Mr. Talcott informs me that rock-foundation can be found anywhere for 600 feet up-stream. The height of guard-walls on the canal-line is regulated as in the slack-water system. The cutting, for about 1,000 feet below the railroad, is very heavy, with considerable rock. The elevation of the rail where the line passes is less than 1,702 feet. The water-surface of the canal is 1,677 feet, leaving little more than 20 feet clear space between the water-surface and the lower chord of the proposed truss, (the grade of the railroad being undisturbed.)

Again, a greater elevation than 1,677 for the comb of the dam would increase the amount of ground overflowed on both sides of the river near the Greenbrier bridge. Accordingly, the elevation of 1,670 for canal-bottom is chosen for the initial level of this division. From this deep cut to where the bluff closes into the river at station 259 the elevation 1,670 for canal-bottom answers very well. Along this bluff, from station 259 to station 308, a retaining-wall is proposed. This retaining-wall is pretty high in places, (20 to 30 feet;) it can only be made lower by increasing the amount of cutting or by moving the wall into the river. The cost of the former would probably offset the saving in the amount of retaining-wall, besides increasing the amount of excavated

material to be disposed of. The latter would decrease the available space in the valley for the passage of floods. I cannot recommend this, with the present lack of data.

Mr. Talcott's notes, copied above, estimate the cutting along this bluff at ⅔ solid rock and the rest loose rock. This estimate was probably for through-cut. I have assumed a less proportion of solid rock, one-half in the worst places. With the retaining-wall on the river-side, the quantity, absolute and relative, of solid rock-cutting is diminished, while where solid rock is reached, the side of the cut will be more nearly vertical than I have assumed.

Between station 333+50 and 339 a retaining-wall is again proposed, to avoid cutting more deeply into the bluff at the mill-dam.

At station 345 the first lift-lock is located It is a question whether it would not be better to locate it on the flat above the mill dam, to lessen the height of the embankment and retaining-wall from station 326 to 337. The line is recommended as it is, for the reason that effort has been made, where the valley is narrow, to keep the canal-bottom at least 20 feet above the low-water line, to avoid interference from floods. It may be found, however, during the construction of the line, that this change of location is advisable. The question may readily be determined from the record of the highest flood on the mill-dam, if such record exist.

Retaining-wall on the river-side is again resorted to, from station 353+50 to station 372. This wall is generally quite high, at one place about 30 feet. It is not proposed lower for the reasons given above, and because the curve in the line above the bluff is disadvantageous for the location of the lock, which would there become necessary. The location through the flats below this bluff calls for no particular remark. As the map shows the location of each lock and its lift, no special mention of these matters is necessary.

As an alternate to the expensive location along these bluffs, the following is suggested by an examination of the map, viz:

Diverge from the line just mentioned at station 254, and enter by a flight of two locks the pool of a dam on the site of dam No. 5 of the slack-water line. Leave this dam by a guard-lock (canal-bottom at 1,648, probably) on the right bank, and then by a canal through the slough at Ronceverte, locking into the river below the mill, as indicated. Build a dam on the site of dam No. 6, with comb at 1645, (probably,) and then by a lift-lock gain the flats and the original line on the left bank at about station 398. To supply the water for lockage at this point, (which would be, in fact, a secondary summit,) a feeder-canal could be constructed along the bluffs. The location of the alternate line and the feeder is shown on sheet No. 1.

Estimates of the alternate line and the canal-line along the bluffs give the following results:

Line along bluffs	$563,968 93
Alternate	357,543 25
Difference in favor of alternate	206,425 68

The land-damage will be greater in the latter than in the former; the contingencies would probably not differ much, as the foundation of most of the retaining-wall would be laid at low-water. I believe a canal on the right bank at this point would be the more convenient for the local trade.

As this alternate was not anticipated at the time of the survey, our data are not complete, and the estimate is but approximate, though I believe ample in quantity. It would be better if a location for the lower dam were made farther down the river, so that the lift-lock on the left bank would be farther removed from the influence of the overflowing water. I recommend this alternate, subject to a special examination on this latter point. It is more subject to freshets than the line along the bluffs, though this loses much of its force, as the canal-line has several other points of slack-water.

The retaining-wall is in a degree subject to the force of the floods, especially the portion below station 348+11.4, where the flood must necessarily impinge upon it at quite an angle. The retaining-wall is subject to frost, also, though this water-line is comparatively free from it.

The next matter of interest is the question of passing the Second Creek Bend. By a reference to Sheet No. 2, and to the notes copied in the opening of this part of the report, it is seen that, immediately below dam No. 7A, the bluff closes in on the left bank for about a mile and a half. The bluff on the right bank closes into the river above the Second Creek tunnel, Chesapeake and Ohio Railroad, and continues so for more than half a mile. The bluff on the left bank again closes into the river below the mouth of Second Creek, and continues so round the bend.

The canal-surveys were made with the object of tunneling this bend from the lower end of the flats, on the right bank, to the ravine below the bend. Dam 7A was located for the crossing to the right bank. I have concluded, upon a study of the subject, to abandon the tunnel-project, and to recommend a line round, partly slack-water and

partly canal, as indicated on Sheet No. 2. Fortunately, the notes of the slack-water survey supply data for quite an approximate estimate for the line round the bend.

Dam No. 9, with comb 4 feet higher than for slack-water, will permit the line on the left bank to enter below dam 7A, with an elevation of canal-bottom of 1,526. The line can then leave this pool on the right bank at the dam, and pass through the flats and under the railroad, as shown on Sheet No. 2. There is quite a scant space under the railroad, only 17.6 feet from water-surface to the top of the rail. I would suggest that an examination be made before construction for a site for a dam above the mouth of Second Creek. In reply to questions about this matter, Mr. Talcott writes me as follows:

"I think that if you adopt slack-water at this point, it would be better and less costly to make the dam about where the transit-line crossed the river above Second Creek.

* * * * * * *

"In regard to the foundation of the dam above Second Creek, I cannot speak with certainty, for I did not make any close examination at that point, but I am confident that you will find rock in about 10 feet of water, or, say, at the elevation of the ledge selected for dam No. 9. In the elbow, just below Second Creek mouth, the ledge shows in about 12 feet of water, but above the falls and about the lower end of the cliffs, on the right bank, the rock must be higher. I mention this only as a suggestion, for, not having the plans to look at, I may be wrong."

The estimate is made, supposing this lock and dam to cost the same as if the site of dam No. 9 were taken, including guard-bank, while the estimate for the canal is made from the upper site suggested.

The location of the canal round the bend is but approximate, and it may be changed somewhat in plan after an examination of the ground.

To avoid the bluffs opposite Fort Spring, an aqueduct over Sinking Creek, and the bluffs below, the line enters the river before the former bluffs are reached. A dam on the site of dam No. 11, with the comb 6 feet higher than for the slack-water system, (*i. e.*, 28 feet high, canal-bottom at 1,602,) will back the water up for this purpose. The line leaves this pool on the right bank by a guard-lock. From this point the line must remain on the right bank till Alderson is reached.

Throughout most of the distance the construction of the line will be expensive; the cutting will be heavy, and the excavation will consist largely of loose and solid rock. Mr. Talcott, in his notes, referring to the line from station 900 to 1030, says, "At least 75 per cent. of the excavation will be solid rock, and the remainder loose rock and earth, the latter in small proportion." In the estimates I have classed the excavation differently, for I have made very little thorough cut, and, the slopes being assumed one in one nearly the entire distance, the areas of excavation will be much larger than will be necessary when solid rock is met with. I kept the area of excavation large, as I wished to make a location which would be found practicable in the actual construction; and then, to compensate for this in the estimates, I classified the excavation as nearly all loose rock, the remainder earth.

The table of estimates accompanying this report is so arranged that any other classification may readily be made if desired. About 1 mile above Alderson, on the right bank, the ground becomes very favorable for a canal, and continues so for about 9,000 feet; then for more than 3 miles the ground is generally unfavorable, and a canal along the hill-side would on this bank be very expensive. Near station 1300 the ground again becomes favorable, and continues so for nearly a mile, when the steep ground again comes close to the river, and canalling would be very expensive for more than a mile. Near station 1410 the hill recedes from the river, and a broad flat affords excellent ground for a canal to station 1526, a distance of about 2 miles. Again the ground becomes difficult for more than 2 miles farther, or nearly to Graham's Ferry.

Upon the left bank, commencing at Alderson, the ground is favorable till Wolf Creek Mountain is reached, where if a canal occupies the hill-side the railroad must be put into a tunnel 1,700 to 1,800 feet in length.

Immediately below, the ground is very favorable for about a mile and a half, when if the canal be kept out of the river the location of the railroad must be changed for about a mile and two-thirds, passing through two tunnels on the way. From station 430 to Graham's Ferry the left bank is very favorable for the location of the canal.

With the view of presenting data for alternate estimates, the surveys included both banks from Alderson to Graham's Ferry, and the lines have been located accordingly, as follows:

1. A line from station 1018 (being a continuation of the line described above) to Graham's Ferry, with the object of avoiding the crossing at Alderson.
2. Crossing at Alderson and remaining on the left bank to Graham's Ferry.

1st. From station 1018 the line continues through the flats till the steep hill-side above Muddy Creek is reached. Here the line goes into slack-water to avoid the difficult ground above and below Muddy Creek, and the aqueducts over this and the several streams below. The line passes into the slough by a flight of two locks, and then

crosses the island as indicated, locking into the river with canal-bottom at the elevation 1520. The surveys did not include this island, and the lock may not be in the most favorable place. A dike is proposed along this slough and on the island to keep out the floods from the flight of locks to the lock at the head of the pool.

The estimates for excavation and embankment in this locality are but approximate, but it is believed they are ample. The elevation (1520) for canal-bottom in the pool is thought attainable from the bottom elevations shown at dam No. 7. This is 1 foot lower than the elevation for the slack-water line in the pool below this dam. An examination may show the elevation 1521 to be better

The object of this slack-water being to avoid the steep hill-side and the aqueducts from Muddy Creek to station 1300, a site for a dam was at first thought of near station 1296.

Mr. Talcott informed me by letter that a good foundation for a dam could be found anywhere between Wolf Creek and dam 18. A location was begun for a canal on the right bank from this dam to the lower end of the flats below. But in this distance the river has but a few inches fall and a slack-water reach made to avoid the bluffs below might as well extend up to the proposed dam. I finally decided to use the site of dam No. 18, then to leave this dam by a guard-lock on the left bank, and by a short canal and lock to again enter the river above the mouth of Wolf Creek. I prefer this method to locating the dam farther down and locking directly from pool to pool, because the boats will now pass from one pool to the other pretty well removed from the influence during high water of the currents near the dam. The guard-lock as located permits passage through the guard bank some distance from the dam. In the pool below dam No. 18 the elevation 1506 is taken for canal-bottom. Special examination may show that it will be advisable to increase this 1 foot. This stretch of slack-water is to be formed by a dam below the bluffs on the right bank. Leaving this dam by a guard-lock, the line proceeds through the flats on the right bank, and, to avoid the bluffs above Graham's Ferry, again takes the slack-water, formed by the pool of a dam on the site of dam No. 21. Below this dam the railroad crosses the river and slack-water is again resorted to, by which the line passes under the bridge.

2d. Alternate line on the bank from Alderson. Returning to station 1018 on right bank above Alderson, and leaving the first described line, the alternate enters the pool of dam No 16, with canal-bottom at the elevation 1540. It may be that this pool might be entered with this elevation just below Rattlesnake Shoals, more than a mile above, thus saving the excavation of that length of canal. But it is probable that the approach to and exit from the locks would not be as convenient at any point above their proposed location. Besides, more locks would be necessary in the flight, or much shorter levels would be required. The latter would not be desirable, and the former would render double locks necessary at the outset. The elevation chosen for this dam is the same as adopted for the slack-water. A higher dam would require greater expense for changing the railroad, while a lower one would require an increase in the already heavy cutting through the town of Alderson. The line leaves this dam by a guard-lock, and to make room for it on the river-bank it will be necessary to change the location of the railroad and the railroad-depot. This relocation has been made by Lieutenant Maguire. It can be but approximate above the dam, as the surveys did not include that ground.

Below Alderson the line requires no special mention till the long curve is passed, nearly 3 miles below the dam. Here, from insufficiency of room outside the railroad, the line passes into the slough. Dikes along the islands and across the sloughs will keep the floods out of the canal. At Wolf Creek a location has been made for the canal on the side-hill, and a location has been indicated on the map for the railroad, by which it is thrown into a tunnel till this mountain is passed. The map suggests at this point a similar alternate to that at Ronceverte, viz, to construct a dam at the location indicated below the bluff. This location was surveyed for a canal-dam. Then, from the pool of this dam, lock up to the flats and connect with the original line. This will require a feeder along the hill-side to supply water for this secondary summit. The alternate line diverges from the first location at station 202, and enters the river with the elevation 1506, for canal-bottom, as proposed for the line from dam No. 18.

Estimates made of the two methods of passing Wolf Creek Mountain, give the following comparison:

Canal-line along bluff, railroad in tunnel, from station 225 to station 271..	$345,458 50
Alternate slack-water and feeder canal, from station 206 to station 271..	221,870 10
Difference in favor of alternate..	123,588 40

The former estimate would be greater if it included the distance from station 206 to station 225.

The estimate for the tunnel supposes the rock to stand without lining. The tunnel is for a double-track road. The objections to slack-water, particularly as the dam is low, are here very well provided against, as the boats in the up-stream approach to the

locks at the dam will be quite out of the immediate influence of the overflowing water, and a crib-work of little extent would make them still more secure. The feeder-canal will require an unimportant change of the railroad. This change is included in the above estimate. Through the flats below, the line requires no special remark.

From station 344 to 430, there is no room for a canal between the railroad and the river. If the canal be kept on the river-bank the railroad must be put into tunnel from about station 360 to about station 380, and again for about 550 feet through the spur at the foot of the islands. In that case the canal can keep in the slough between these tunnels by raising the present railroad embankment slightly. The railroad must of course pass along the hill-side inside the slough. The slack-water device may be again availed of, to avoid this change in the railroad, as follows: Diverge from the first line at station 344, and enter the river by a flight of locks. The elevation 1497 can probably be attained for canal-bottom. Build a dam on the site of dam No. 20, and then by a second flight of locks ascend to the flats on the left bank, and join the first line as indicated on the map. (Sheet No. 2.)

A feeder must be built to supply the secondary summit near station 450. The construction of this feeder is somewhat complicated. The elevation of the canal-bottom at this secondary summit is 1513. The canal-bottom has the same elevation at station 344, where the alternate leaves the first line, and the summit near station 450 must then be fed from above the lock at station 332. The surface of the canal at station 450 is at the elevation 1520. The canal-surface at station 332 is at the elevation 1528. The distance between these two points is more than 2 miles; the fall in water-surface is 8 feet. All of this fall cannot be used unless the railroad were raised for a distance of about 2 miles. The elevation of the track at station 351 + 47 is but 1524, leaving but 4 feet of fall available between this point and station 450. The space outside the railroad and along the bluffs below Albert's Gut is very restricted, and the section of the feeder should be as small as possible. To overcome the difficulty, a wide cut is proposed from the summit, near station 450, to the slough above. This practically extends the summit-level up to the head of the slough near station 380. Then by closing the outside of Albert's Gut a reservoir is formed, which is the upper extremity of the feeder. The surface of the feeder at this point is taken at the elevation 1522, which permits a fall of 2 feet to the summit at station 381. Room may then be obtained for the feeder outside the railroad without disturbing it.

The reservoir at Albert's Gut may be supplied from the canal above the lock at station 332, by a short feeder-canal inside the railroad, the water being permitted to flow from the main canal to this feeder and under the railroad, the track passing over the cut on piers and longitudinal timbers. A similar change in the cut from one side of the railroad to the other will be necessary before station 450 is reached. The change is indicated between stations 426 and 427. It is proposed to carry the track over on piers, permitting a free space of 100 feet for the flow of water from the left to right of the railroad.

In considering this slack-water alternate with that at Wolf Creek it will be seen that, if both be adopted, the Wolf Creek feeder must supply both secondary summits and the entire canal from station 270 to Graham's Ferry. It has been estimated accordingly, and to decrease the amount of water necessary the locks, both at the dams and at the head of the pools, have been arranged in flights, although the guard-walls of the lower lock should be carried nearly or quite as high as the walls of the upper one of the same flight. Were it not for the desire to decrease the amount necessary, a single lock of double lift would answer the purpose.*

Estimates of cost give the following for comparison of the original line and this second alternate:

Canal along the bank and through the slough, the railroad being put into tunnels and on to the hill-side from station 344 to lock at station 483..	$499,259 18
Alternate, station 344 to station 483	268,224 98
Difference in favor of alternate	231,031 20

The railroad-tunnels are for double track and are supposed not to require lining.

The two alternates save on the estimated cost a total of $384,623.60.

From station 483 to Graham's Ferry the location is simple. At this latter point the line as recommended enters the river to pass under the railroad as recommended for the line on the right bank. The comparison of cost of the two lines from Alderson to Graham's Ferry can now be made.

* With alternate passages no water is saved in dividing the entire lift into several smaller ones. Alternate passages may be infrequent, and therefore there will be a saving of water by using several locks of less lift, instead of one lock of greater lift. There may be a saving in first cost by constructing a single lock of sufficient lift at the outset. Then, when the commerce of the line increases sufficiently, the second lock of the flight might be built, and the lift of the first diminished by half.

Right bank.

Station 1020 to lock at head of pool above Wolf Creek	$331,222 26
From pool at Wolf Creek to canal dam No. 4 and lock	135,541 62
Canal dam No. 4 to Graham's Ferry	211,494 50
Total	678,258 38

Left bank.

Station 1020 on right bank above Alderson to station 225 above Wolf Creek	$389,890 59
Station 225 to 271—slack-water alternate	221,870 10
Station 271 to 344	52,478 85
Station 344 to 483—slack-water alternate	268,224 98
Station 483 to Graham's Ferry	111,026 17
Total left bank	1,043,490 69
Deduct estimate for right bank	678,258 38
Left-bank estimate exceeds that for right bank	365,232 31

If the slack-water alternate be rejected for the line on the left bank, the difference against the left bank will be $749,856.91.

The estimates are exclusive of land-damages, the difference in which could not be so great as to affect the decision with the above disparity of cost. The right bank is recommended.

Before proceeding further in the detailed description of the canal-line proposed from Graham's Ferry, it will be advisable to consider the Great Bend (sheet No. 4) as a whole.

When the surveys began I was of the opinion, from what had been recommended in previous surveys, that the Second Creek Bend would, without doubt, be tunneled for an ordinary canal-line, and that the Great Bend would be passed by a tunnel, whether canal or slack-water were adopted from Kanawha Falls to the Greenbrier Bridge. So confident was I of this, that I gave instructions that the canal-survey need not be carried round the Second Creek Bend, and I was also thoroughly convinced that it would be a waste of time to survey the river round the Great Bend. Accordingly, in the former case, only the slack-water line was run, and our data supply but approximate estimates for a canal, but I am confident they are ample.

Further study of the subject of tunnel cuts-off for navigation modified my views, and I telegraphed to Mr. Talcott, in the field, to carry the slack-water survey around the Great Bend. I still adhered to the purpose of tunneling here for the ordinary canal. I have abandoned all the tunnel cuts-off. The objections to a slack-water tunnel through the Great Bend, mentioned in the description of the slack-water line, apply to the canal project also. These objections are, difficulty of approach, expense, accumulated lockage at the down-stream end, whereby a long flight of locks (double) would be necessary in a narrow ravine and creek-bed, and a loss of time, offsetting, in a great measure, the gain in distance.

Fortunately, the notes of the slack-water survey, carefully collated, demonstrate that a line round the bend is practicable at moderate expense. It has been noted that the lines from Alderson to Graham's Ferry unite above the railroad-bridge, passing under in a slack-water pool. This is necessary, as the canal-line should not cross the railroad at or near a grade. As the railroad crosses from one bank to the other, both lines (left bank and right bank) are compelled to pass in the same manner.

To form this slack-water pool, a dam is proposed below Bacon's Falls at station 1876 + 22. The availability of this site was shown in the description of the slack-water line. This dam will be about 27 feet high. The line will leave this pool by a lift-lock on the left bank. I recommend that this lock be built as a guard-lock inside the dam, and a lift-lock outside, so that, when there be a rise on the comb of the dam, the upper or the guard lock will become a lock with a lift equal to this rise. Otherwise, from the great height of gates necessary, the maneuvers might be too difficult in a high flood. With an ordinary guard and lift lock the lift would be the normal lift increased by the height of the flood. Security is offered against accident by dividing this entire lift into two of less height. From this dam the line keeps on the left bank, as shown, to about station 2050, passing over Stoney and Little Stoney Creeks on aqueducts, and inside the knoll at the Blue Hole. At about station 2060 the hills close into the river on the left bank, and the ground opens on the right. A dam at this point, of sufficient height to cross to the flats oppo-

site, would supply slack-water navigation from above Stoney Creek. If the crossing were made, the same difficulty would be met with round the next bend, where, if a crossing were made, the water would be backed, to the previous crossing, with sufficient depth to afford a constant slack-water navigation. The same state of affairs would exist at the lower end of the flats below the second crossing. The best solution of this is, probably, to enter slack-water at station 2050, locking down 13 feet for this purpose. Then, if a dam be built near station 2150, with comb at the elevation 1,427, the pool of a dam on the site of dam No. 29 may be attained by a lift of 10 feet. The latter dam will permit the line to leave on the right bank, by a guard-lock, at sufficient height for crossing the creek below. It may be necessary to locate the former dam lower down than indicated.

Mr. Talcott writes me that "Good foundation can be had for a dam some distance above dam 28, but I do not know certainly of any at the head of the flat on left bank. I think, however, that you would be safe in assuming a good one anywhere there if you allowed a good sum for the foundations."

The location from the dam below Bacon's Falls is approximate only, and a special survey would probably modify it in detail, both as to plan and the location of the locks. In the estimates my endeavor has been to have the quantities full; I believe the excavation will be found in excess. Masonry can be more closely approximated to. The estimated cost of the line round the bend ($898,392.86) is much less than what the tunnel cut-off could be.

From the ravine at the western portal of the Great Bend tunnel (Chesapeake and Ohio Railroad) to the junction with the New River division the location was made by Lieutenant Maguire. From the ravine the canal keeps on the right bank to station 248 of the line from the tunnel-portal, passing over Powley's and Big creeks on aqueducts of small span. At station 248 the line enters the pool of a dam on the site of dam No. 32, with canal bottom at the elevation 1,368.8, (according to the Greenbrier levels.) At dam No. 32 a guard-lock on the right connects the Greenbrier and the New River divisions. The quantity of retaining-wall necessary and the heavy excavation render this section quite expensive.

It might be found on examination that the following line would be an available and a desirable substitute, viz: Leave the dam near 2150 by a guard-lock on the left bank, and then, by canal, through the flat, enter the river where the bluffs close in below, with the elevation 1,396 or less for canal-bottom. Build a dam at the site 30 A, with comb at elevation 1,403 or less. This dam would not be more than 23 feet high. Lock down from this dam to the elevation 1,386 or less, according to location above. At station 194 build a dam with comb at the elevation 1,393 or less. There is a rock foundation here. The dam would be 24 feet high. Lock down from this dam to elevation 1,376, (probably.) Build a dam on the site of dam No. 32, with comb at the elevation 1,383, (probably,) and there, by a guard and lift lock, as at 1876+22, connect with the New River division. This last dam would be 19 feet high, and the lock 7.2 feet lift, (probably.) This method would add but one more slack-water pool to the line, and I should expect a saving of about $300,000 in the estimated cost. The data now at hand are not sufficient for an accurate estimate of this substitute, and in the project offered I wish to have as little conjectural as possible. The Great Bend should again be surveyed for the accurate location of the line, and the examination for this suggested substitute could be made at the same time. A good amount might be saved on the estimates by going into slack-water above Powley's Creek, but it would be as well to examine the above substitute before adopting either. Detailed estimates of cost accompany this report. The estimates have been subdivided, so that a comparative estimate of any change, however small, may be readily made at any time in the future.

The earth-excavation for locks is estimated at 10 cents extra per cubic yard to cover the replacing of this earth as an embankment on the sides of the locks. When possible, the excavation is intended to supply the embankment required. The possible difficulty of procuring good stone for cut masonry was mentioned in the report of the summit division.

Nearly all the estimates of quantities for the Greenbrier division were made by Lieutenant Maguire. Mr. J. L. Seager made those for the slack-water alternates exclusive of lock masonry. The estimates for the recommended canal-line for the Greenbrier division aggregate $4,538,349.85. The slack-water estimates exceed this by $1,712,940.17.

I have not considered it necessary to prepare a comparison of their respective advantages in the Greenbrier division, as I suppose the decision of the question whether the canal or the slack-water shall be chosen will depend on the New River division. It may be well, however, to note that on the Greenbrier the canal-line as recommended consists in good part of slack-water, while the slack-water system consists in a good part of canal.

RECAPITULATION OF ESTIMATES FOR CANAL-LINE AS RECOMMENDED.

Greenbrier division.

Howard's Creek to station 254		$231,860 43
Station 254 to station 397 slack-water alternate, avoiding canal along bluffs at Ronceverte		357,543 25
Station 397 to pool of dam No. 9		99,208 38
Dam No. 9 to dam No. 11 and lock, inclusive		433,165 64
Dam No. 11 to station 1020		626,279 60
Station 1020 to pool at Wolf Creek		331,222 26
Pool at Wolf Creek to Graham's Ferry		211,494 50
Great Bend section		898,392 86
Great Bend to mouth of Greenbrier		799,805 67
		3,988,972 59
Guard-cribs at 12 dams, at $5,000		60,000 00
Land damage:		
48 miles long and 0.06 mile wide (316.8 feet) = 2.88 square miles = 1,843.2 acres, at $25		46,080 00
Grubbing and clearing:		
48 miles long and 0.02 mile (105.6 feet) wide = 614.4 acres, at $50		30,720 00
Contingencies, 10 per cent		412,577 26
Total canal estimates, Greenbrier division		4,538,349 85
If line along bluffs at Ronceverte be adopted, there must be added to above estimate	$206,425 68	
Contingencies, 10 per cent	20,642 57	
		227,068 25
		4,765,418 10

All of which is respectfully submitted.

THOMAS TURTLE,
First Lieut. of Engineers.

Maj. WM. P. CRAIGHILL,
Corps of Engineers, U. S. A.

REPORT ON RE-EXAMINATION AND SURVEY OF THE NEW RIVER DIVISION, SURVEY OF 1874, BY MR. N. H. HUTTON, ASSISTANT ENGINEER.

BALTIMORE, *May* 28, 1876.

COLONEL: I have the honor to submit the following report of the results of the re-examination and survey of the New River division of the central water-line, made under your direction during August, September, and October of 1874.

Your instructions, dated July 15, 1874, said * * * "not later than August 1, you will enter upon a resurvey of the Greenbrier River below Howard's Creek, and of New River below the Greenbrier, the object being to fix the precise location of dams and other details of the slack-water navigation of those streams, with the collection of such additional information as will enable a detailed determination to be made of the location and cost of the canal which, by some engineers, is considered a necessity for that part of the line, and by others a desirable though not a necessary alternative to the slack-water. You will keep in view also the possible advantages to be gained by resort to tunnels for avoiding difficult places, in the valley of New River especially, and thereby at the same time shortening the line, either for canal or slack-water navigation."

"It is desirable, if possible, that the information you will gain be such as to enable the work along that portion of the line to be put promptly under contract should Congress provide the means." * * * * *

Under these instructions, the organization of two engineering parties was at once commenced, one for the examination of the slack-water scheme and the other for the survey of an independent lateral canal.

On the 1st of August both parties were assembled in camp at the mouth of Howard's Creek, and operations were commenced at that point. A rapid reconnaissance meantime was made of the valleys of the Greenbrier and New Rivers, which developed the impracticability of procuring, over this whole distance, the amount and quality of information called for by your instructions with the time and money at my disposal.

I was accordingly relieved of the duty of examining the Greenbrier division, and the parties under my charge were transferred to the New River, at the mouth of the Greenbrier, where the field-work was resumed on August 8, continuously carried forward to Kanawha Falls, and completed about November 1.

Throughout this division (62 miles in length) transit and level lines were run by both parties, and soundings were made, where practicable, to determine the form and character of the river-bottom, depths of water, &c.

Using the survey of 1872 (made under the late Mr. E. Lorraine) as a basis, sites for locks and dams were selected, surveyed, and marked in the field, the governing considerations being that all dams should be located on foundations of solid rock, should, if possible, be at least 600 feet long on the crest, and that they should nowhere endanger, by overflow, the track of the Chesapeake and Ohio Railroad during floods of equal volume to that of 1861.

An experimental line for a lateral canal, with cross-sections of the surface at every hundred feet, was traced and marked from the last dam on the Greenbrier to the pool above Kanawha Falls, a distance of 60 miles. The location was governed by the consideration that the top of the tow-path bank should be two feet above the flood-line of 1861, the marks of which were obtained and noted wherever practicable.

Detailed surveys and measurements were made to determine the cost of removing from the river-bed the masses of loose rock which now encumber it between Keeny's Shoals and Narrow Falls, a distance of about 20 miles, through what is sometimes called the "gorge" of New River.

Surveys were made with a view of cutting off bends in the immediate valley of New River by means of tunnels, wherever practicable, and extended reconnaissances and surveys were made to determine the practicability of suggested lines using tunnels outside the limits of the immediate valley, and cutting off large sections of the river proper.

Since the completion of the field-work, the want of money has greatly retarded the preparation of maps, drawings, and estimates of cost, which have mainly been done by the office staff when they could be spared from other duties. Nevertheless, it is believed that the papers, drawings, &c., herewith submitted furnish all the information called for by your instructions.

PLANE OF REFERENCE.

The levels, as marked and described on the maps, drawings, profiles, &c., refer to elevations above tide-water at Richmond, Va.

The basis for all the levels was a bench-mark on the left bank of the Greenbrier, near our initial point, established by the party under the late Mr. Ed. Lorraine, in 1872. This bench-mark was, in turn, established by levels based upon a bench-mark established by parties under Mr. W. R. Hutton, in 1870, on the left bank of the Greenbrier, near the mouth of Howard's Creek, the levels having been brought over the Alleghanies by these parties.

During the summer of 1874 other lines of levels were brought over the Alleghanies by parties under Lieut. Thomas Turtle, United States Engineers, which were found to differ somewhat from those of 1870, and upon their prolongation to the mouth of the Greenbrier this difference was increased largely, so that, according to the last levels run, our bench-mark at initial point was 4.8 feet too low. This discrepancy was not discovered until the field-work and notes of both divisions were completed, and, in order that the drawings might correctly represent the contents of the note-books, the original levels have been retained and marked, so that the water-surface at dam No. 32 of the Greenbrier division appears to be 4.8 feet higher on the maps and profiles of that division than the level of the same point appears to be on the maps and profiles of the New River division. In other words, to reduce the levels of New River division to correspond to those of the Greenbrier division, 4.8 feet must be added to them.

GENERAL FEATURES OF THE COUNTRY.

The New River, throughout the portion which was embraced within the limits of this survey and report, presents in various degrees of development in its different sections the contracted valley and sudden changes of slope usually found in streams flowing through mountainous districts. Between the Greenbrier and Kanawha Falls, the river may be divided into four sections, possessing, in varying and increasing proportions, from the upper to the lower end, the characteristics referred to.

The first section (about 15 miles long) extends to Meadow Creek, with an average fall (excluding the abrupt fall at Richmond's) of about 7 feet per mile. The valley, though narrow, presents usually on one side or the other strips, at least, of bottom-land, and the hill-slopes are not continuously precipitous.

The second section (about 25 miles long) extends to Sewell, with an average fall of about 9 feet per mile. The valley becomes more contracted; bottom-land (properly

so called) has almost entirely disappeared, its only representative being short stretches of high bench-land. Vertical cliffs impinge more frequently upon the water's edge, and the hill-slopes are everywhere ragged with masses of rocks detached from the cliffs, always found at short distances in the rear. At this point (Sewell) is usually said to commence the "gorge" where the river breaks through the high lands connecting the Gauley Mountains with those of Coal River.

The third section (12 miles in length) extends to Hawk's Nest, with an average fall of 17 feet per mile. Throughout this, as well as the following section, the river has cut its way over a thousand feet deep through the highlands, and were it not for the more friable nature of the materials encountered, (sandstones and shales,) would present all the features of a veritable cañon as found in the metamorphic regions of the Great Basin.

Both valley and river-bed are very much contracted, with steep slopes of loose rock thrown down from the cliffs. The water-way is frequently clogged with large masses of rock, through which the river alternately rushes with violence in many narrow streams, or eddies in deep and sluggish pools.

The fourth section, extending to Narrow Falls, about seven miles in length, has an average fall of 19 feet per mile, and is the culmination of the gradual increase of ruggedness, contraction, and slope. Though the average fall, as stated, is 19 feet, there are several miles in which the fall is nearly 30; there can hardly be said to be any *valley*; the vertical and at times overhanging cliffs rise abruptly from the water's edge, or are at best only separated from it by a sloping mass of loose rock of all shapes and sizes; the masses of rock cumbering the water-way appear at times almost to have absorbed the river, which truly offers at first sight small chance for improvement. From this point (Narrow Falls) to the Kanawha Falls the river extends in a wide pool of varying depth, the side-hills come closely down to the river until the Gauley enters on the right bank, from which to the falls the valley expands on that bank in a wide flat. The width and depths of water-way on this whole division vary so frequently and so greatly, that it would be impossible to give an accurate general statement of them; it may, however, be roughly said in the first section the width is from 400 to 800 feet, with a depth of from 7 to 12 feet in the pools; in the second section, from 250 feet to 400 feet, with the same depths in the pools; and in the third and fourth sections it rarely ever exceeds 250 feet in width, and is often less than 200 feet, with depths in the pools as great at places as 30 to 40 feet.

It flows in alternating pools and rapids, with depths in the latter varying from a few inches in the upper sections of the river to 10 feet in the lower portions. The only vertical falls encountered are Richmond's, about ten miles below the Greenbrier, where the river falls 28 feet, 15 feet being nearly vertical over a ledge of hard, conglomerate sandstone; and Kanawha Falls, where it descends 19½ feet over a ledge of sandstone. In both cases the river has a width of over 1,000 feet on the high-water crest-line, and immediately above the river is very shallow. At Richmond's Falls, the hill-slopes, or cliffs, come closely down to the water's edge on both sides of the river; at Kanawha Falls, the hills come down closely on the left bank, and a wide, low bottom extends along the right bank.

The Chesapeake and Ohio Railroad occupies the right bank of the river, from the Greenbrier to Hawk's Nest, and the left bank thence to Kanawha Falls. The rock exposed throughout is mainly a compact sandstone, in nearly horizontal beds, occasionally overlaid with red shale, and sometimes merging into a hard conglomerate, as at Richmond's Falls. The hill-slopes are generally formed of *débris* from the adjacent cliffs in the upper portion, to some extent mixed with alluvial deposits; but lower down they form, as before stated, almost pure masses of detached rock. A large majority of the shoals are composed of loose rock and bowlders forming dams, over and through which the river flows, and which have apparently (after the manner of the formation of "pot-holes") abraded and broken up the bed-rock to great depths, rendering these apparently natural sites for dams actually the least desirable, in so far as foundations are concerned. For this reason it will be found that in the present project the dams are frequently located in the deep water, above the shoals, giving an increased height of masonry, but securing undoubted rock-foundations. Except at the shoals, the soundings indicated generally a bottom of rock in place, with little or no deposit overlying it. The bottom-lands have generally a loose, sandy soil, in most cases intimately mixed with *débris* from the cliffs.

The side-hills are almost entirely destitute of anything like soil in masses, such as there is being swallowed up in the crevices of the loose rock which everywhere covers their slopes. Nevertheless, walnut and poplar timber, of large size and excellent quality, abounds on these slopes throughout the whole distance.

The sandstone everywhere found is of excellent quality for building purposes, and easily quarried, in immediate proximity to the sites where required for use.

The question of water-supply does not enter into the discussion of any method of navigation-improvement, as its abundance is undoubted, its superabundance during freshets being the most formidable obstacle.

Until the construction of the Chesapeake and Ohio Railroad, owing to the scarcity of arable land, the valley between the Greenbrier and Kanawha Falls was an unknown land, except to parties of surveyors or hunters who at long intervals forced their way down it. Owing to this absence of settlement, we have not only no accurate record as to the volume, frequency, and duration of floods, but not even the ordinary hearsay information usual in such cases. The wild and gloomy appearance of the river through the "gorge," as seen from the cliffs above, has doubtless caused an exaggeration of their heights and violence, great as they undoubtedly are; but that they attained great heights, with extreme rapidity, is all that we really do know. During the summer of 1861 occurred a freshet which is admitted by the few old settlers scattered throughout the valley to have been the greatest known for forty years; and of this some few records of heights are obtainable, though that they are uncertain may be admitted, when it is known that at one point a difference was found of 7 feet in the elevations, as given by different persons claiming to have seen and noted the flood at its height. However, this flood, and the measures of it thus obtained, have, since its occurrence, been used as the standard of reference by the Chesapeake and Ohio Railroad Company and for all projected improvements of the river, including the projects herewith submitted. To determine its volume, reference has been had to its reported observed height of 8 feet just above the crest of Richmond's Falls.

It has been assumed that for a length of 1,200 feet (which is less than the development of the crest-line by probably 15 per cent.) the discharge was equivalent to that over a weir having 8 feet depth above the comb. This would give a volume for this flood of about 90,000 cubic feet per second, which is the amount that has been assumed heretofore as well as in this project to determine proportions of guard-walls and banks and the heights of dams with reference to the railroad. From observations at other points of the water-marks of this flood, combined with the cross-sections of the valley, I am inclined to the belief that this estimate of quantity is exaggerated. It is true that the data available are too rude for other than a very approximate solution of the question, and altogether insufficient to justify the construction of works on any other basis previous to the procurement of more reliable information. The matter is referred to simply to call the attention to the *possibility* of greatly lessening the cost of any scheme of improvement by the aid of more full and reliable data as to the floods. The reasons for a belief in this possibility are twofold; in the first place, the observed height of 8 feet at Richmond's Falls was toward (if not on) the left bank, from which extends, for more than half the total width of the river an irregular island, (or peninsula,) immediately below the crest of the falls, at some points really connected with it, at many nearly of equal height, and covered throughout with loose rock and a dense growth of timber, which during this great freshet was in full foliage. It seems almost impossible that this obstruction to the free escape of the water should not have caused an elevation of the level of the crest on this part of the line over that portion which afforded a free discharge, and consequently the assumption that 8 feet was the average depth is an overestimate. Secondly, a comparison of the observed heights of the flood, at some points, with the cross-sections of the valley, with liberal allowances for the unknown and for errors in the known quantities, indicates a volume not exceeding 60,000 or 65,000 cubic feet per second. Should this assumption prove to be true, it will result that the project as now presented will tax the work with difficulties of execution and operation in excess of any probable requirements. The evidence of flood-heights in the "gorge" of 50 to 60 feet was, at the time of this survey, confined to a single log lodged in the cliffs, in the right bank, below Cotton Hill station. This undoubtedly presented evidence of abrasion, as if by contact with water and rocks, yet it may have come down the hill and not up, for almost immediately below it (about 30 feet) is a cave or hole in the cliffs, so situated that it would seem impossible for all, if any, of the drift entering it to escape; yet a careful investigation failed to discover any signs of such deposit within it.

SLACK-WATER IMPROVEMENT.

The general arrangements for this method of improvement, as set forth in the report of survey in 1872, made under your direction by the late Mr. E. Lorraine, necessarily formed the basis of operations for this re-examination. There remained only to be determined the feasibility and costs of eliminating from that project certain features (mainly relating to the foundations for and length of dams) which were considered objectionable.

The question of water-supply, as before stated, does not enter into the question, except as to protection against its superabundance.

The result of the re-examination will probably be more readily appreciated by a summary of the leading features of the former project and that now presented for consideration. As arranged and estimated for in 1872, the plan embraced (between the mouth of Greenbrier and the pool below Kanawha Falls) 38 dams, 9 of which were located on foundations of loose rock. Their average length on crest was 581 feet; mini-

mum length, 317 feet; and average height above foundations, 25¼ feet. (The maximum lift at any one lock being 25 feet.) The project, as now presented, proposes 33 dams, all located on solid-rock foundations, with an average length of 709 feet, a minimum length of 550 feet, a mean height of 24 feet, and a maximum lift of 22 feet, making, as compared with the former arrangement, a decrease of 5 in the number of dams, or 13 per cent.; an increase of 128 feet in mean length, or 22 per cent.; an increase of 233 feet, or over 60 per cent., in minimum length; and a decrease of 3 feet in maximum lift, without material change in the average height above foundations of the dams. The diminution of the number of dams, without increase of height, is proposed to be obtained by a resort to sections of lateral canal around some of the greater descents, and by the excavation of channels through the shoals next below the dams, in order to utilize the natural depths of water found at their feet.

The increase of mean and minimum length is proposed to be obtained by building the dams obliquely to the thread of the current in one or more branches, and by the location of the locks and lateral canals as far into the hill-sides and away from the low-water border as circumstances will permit. This latter arrangement affords the greatest possible development of crest-line, as it obtains nearly the entire distance between the level contours on either side of the valley corresponding to the reference of the comb of the dam. It evidently, however, requires very considerable excavations to form approaches to the locks, and in some cases the removal of projecting points of the side hills above and below the dams, to permit the free access and discharge of flood-waters. On the other hand, in addition to the increased length of the dams, it partially removes the locks from the more violent assaults of the floods, and is believed to afford the nearest practical approximation to compliance with the suggestion that the locks should be located in lateral ravines, entirely removed from the river-bed, for the reason that these are always narrow, rugged, and precipitous, liable to frequent and violent floods of short duration, which bring down masses of stone and timber, rendering them, if anything, more dangerous than the main stream to the stability and security of the works.

Examinations for tunnels were made across all the principal bends of the river that would be accessible to either a canal or slack-water improvement. The location of the Chesapeake and Ohio Railroad would prevent (with any reasonable degree of economy) the approach to any possible tunnel occupying the same side of the river as the road, and consequently no examinations were made on that bank, except at the Stretcher's Neck Tunnel.

Tunnel-line No. 1 passes through the first bend above Stretcher's Neck, leaving the river above Quinimont Station and striking it again immediately opposite the entrance to Stretcher's Neck tunnel.

The distance by river is	11,600 feet
And by tunnel	3,600 feet
Or, tunnel-line saves	8,000 feet
The tunnel-line will cost about	$1,750,000 00
And the river-line will cost about	108,000 00
Or, cost of tunnel-line will exceed line around by	1,642,000 00

Tunnel No. 2 is through Stretcher's Neck bend.

The distance by river is	19,000 feet
And by tunnel	2,000 feet
Or, tunnel-line saves	17,000 feet
The tunnel will cost about	$1,037,000 00
And by river will cost about	570,000 00
Or, tunnel-line exceeds in cost by	467,000 00

Tunnel No. 3 is about 5 miles below Stretcher's Neck, and cuts off Buffalo Shoals.

The distance by river is	14,000 feet
And by tunnel is	4,950 feet
Or, tunnel-line saves	9,050 feet

The cost by tunnel is about	$1,230,000
And by river is about	237,000
Or, tunnel-line costs in excess	993,000

Tunnel No. 4 is through the first bend below Hawk's Nest, and is the first one located on the right bank of the river.

The distance by river is	12,000 feet
And by tunnel-line	6,400 feet
Or, the tunnel line saves	5,600 feet
The cost of tunnel-line is about	$1,529,000
And the river-line about	453,800
Or, tunnel cost is in excess by	1,075,200

Tunnel No. 5 is also on the right bank, and cuts off the Blue Hole Bend. The line would, at lower end, strike the river at the foot of Narrow Falls, above dam No. 32.

The distance by river is	12,500 feet
And by tunnel is	7,760 feet
Or, the tunnel-line saves about	4,740 feet
The cost of tunnel-line is	$2,087,500
And the cost by river is	427,178
Or, the tunnel-line exceeds in cost about	1,660,322

Tunnel-lines Nos. 2 and 4 will enable one dam at each place to be dispensed with. The others save nothing in this respect. All the tunnels will require a guard-lock in addition to the same number of lift-locks as the lines by way of the river.

If the adoption of these tunnel-lines would serve in any considerable degree to raise the standard of utility of the slack-water scheme, or, in other words, if their use would enable the whole division to be navigated during floods of greater volume than could be done without them, their construction might be advisable even at a greatly increased first cost. But this would manifestly not be the case, for the reason that those portions of the route not affected by any of the tunnels possess all the characteristics of the portions avoided by them.

The river above tunnel No. 1 presents no greater facilities for the operation of a slack navigation than is found in the bend cut off by the tunnel, and the same is true of the portions between Nos. 2 and 3 and Nos. 4 and 5. Those portions of the river avoided by lines Nos. 4 and 5 undoubtedly offer very formidable obstacles to the construction and operation of any scheme of navigation improvement, and here, if anywhere, the resort to tunneling might be true economy. The river at these places has, for several miles, an average fall of 26 feet per mile, one of the miles, avoided by tunnel-line No. 5, having a fall of about 30 feet. Yet even here the intermediate portions not affected by the tunnels are equally unfavorable with those avoided, and for the "gorge," as elsewhere, the only real gain possible by means of tunnels is that of distance or time.

Assuming 20 minutes as the time required to pass through one of these large locks, and the average rate of travel by boats in the pools as 3 miles an hour, the extra guard-lock at each tunnel will consume an amount of time equal to 1 mile of distance. If we further assume, as is reasonable, that the rate of travel through the tunnels and approaches will be only 1½ miles per hour, there will result the following comparison of times by the several tunnels and by the river, excluding lockages common to both routes:

	Minutes.
Through tunnel No. 1	47
By river	44
Through tunnel No. 2	35
By river	72
Through tunnel No. 3	57
By river	33
Through tunnel No. 4	51
By river	37
Through tunnel No. 5	60
By river	37

So that, even allowing a much less time for lockage and a greater rate of speed through tunnels and approaches than above, the fact remains that there would be no gain in time by the use of any of the tunnels except No. 2, (through Stretcher's Neck.) For these reasons, though estimates of cost are submitted for tunnels, only that through Stretcher's Neck is embraced in the main estimate showing the total cost of the slack-water scheme.

The ultimate utility of the whole project is evidently governed by that of its worst portion, which is the gorge between Sewell and Narrow Falls, and the utility of this section evidently depends upon the number of days during which navigation would be suspended by reason of floods rendering the pools impassable.

The data necessary to a very positive determination of this question are not to be had; yet sufficient is known to enable an approximate solution to be made, which will be satisfactory just in proportion to the certainty that the assumptions are all made against, rather than in favor of, the slack-water navigation. Under certain assumptions, which are in harmony with the facts, in so far as known, a table (hereto appended) has been prepared, showing the discharges and velocities corresponding to every foot in depth, from 1 foot to 14 feet, on the comb of dams similar to those proposed for this part of the work. Assuming that a velocity of four miles an hour at the upper ends of the pools will represent the limit against which such boats as would probably be used on this improvement could be propelled, it will be found by reference to the table that, for the duration of any flood discharge exceeding 37,000 cubic feet per second, navigation by slack-water would be entirely suspended throughout the gorge.

The only definite information on record as to the height and duration of floods is confined to observations made by Mr. E. M. Tutwiler, civil engineer, (at the time in the service of the Chesapeake and Ohio Railroad Company,) who has kindly furnished a profile of his results, which is appended hereto.

These observations were made near Buffalo Shoals, about 5 miles below Stretcher's Neck, and extend over a period of about nine months, from June 12, 1872, to March 17, 1873. The season appears to have been prolific in freshets, no less than ten being noted exceeding 6 feet in height above low water. The extreme range was 19 feet above this plane, and for 247 days out of 278 days, or about six-sevenths of the time, the river was at various stages above low water.

If these observations had included measurements of slope or velocity, or had similar ones been made above and below, so that the volume of discharge at the various heights could have been determined, the question would have at once been settled for all similar years. As this was not done, we can only approximate a solution, based upon assumptions always certainly against the slack-water.

The flood of 1861 (according to marks given by persons who resided in the vicinity at that time) attained at this point a height of about 22 feet, and according to the estimates hitherto used, based upon its depth on the crest of Richmond's Falls, its volume was about 90,000 cubic feet per second.

If we assume that at one-half the height the volume of discharge would be $\frac{4}{10}$, (which is certainly a liberal allowance,) it will result that during the continuance of floods exceeding 11 feet in height at this place the navigation by slack-water would be suspended throughout the gorge.

An examination of the records of Mr. Tutwiler's observations shows that during the nine months covered by them there were four days in January and five and one-half days in February, or nine and one-half days in all, during which this suspension of navigation would have obtained in 1872 and 1873.

Whether this season was a fair average as to high waters we cannot tell with certainty, owing to the absence of records, but it certainly could not be considered a low-water season.

MECHANICAL STRUCTURES.

Locks.—The drawings herewith submitted show in detail the type of locks, gates, valves, &c., proposed to be used as applied to the mean or average lift of 15 feet. In accordance with the resolution of adopting for the locks of the canal division a width of 24 feet, the plans for the slack-water locks have been made 250 feet by 48 feet in the chamber, instead of 240 feet by 40 feet as hitherto proposed and estimated for. The details of gates, valves, &c., are of course only intended as studies, and it is hardly to be doubted but that in the course of construction many improvements and economies can and will be made. The locks throughout are proposed to be protected against submergence by floods of 100,000 cubic feet per second, or 10 per cent. greater than that of 1861. The walls and gates are proposed to be arranged to permit the use of the locks when the river is at the maximum navigable height in the pools. Owing to the fact that the locks are located as far as possible from the water's edge, guard-banks are short and unimportant, the wing-walls frequently being sufficient. It is proposed to found all locks on solid rock, and in preparing the estimates its position was determined, where concealed from view, by reference to its exposure in the river-

bed and in the adjacent hill-sides. The drawings show the upper gates resting on breast-walls; this is proposed to be done only when the excavation is in solid rock, or in other special cases; generally, the upper and lower gates will have the same height, in order to prevent a water-fall at the head of the chamber when using the valves in the gates to fill the lock.

The lock-flooring of timber and concrete, shown and estimated for in each lock, is only proposed to be used where the rock is seamed or imperfect, a matter only to be determined by actual experience.

It is proposed to build the chamber-walls of rubble-masonry, "pointed off" on the interior, and the head and tail walls of random-ranged masonry, dressed on exposed faces.

The walls have been designed to resist the pressure of the water when at flood-height, supposing the chamber filled with water to the lower level.

The European practice appears to be to consider the lock-chamber empty and the exterior water at flood-height; but as this method would greatly increase the volume and cost of masonry, and could only be demanded by the possible necessity of emptying and repairing the lock-chambers during great floods, it has been thought an unnecessary expense for this project, as the emergency, should it arise, could be met by bracing the walls from the interior.

The details of the wrought-iron gates are adapted to this project, mainly from the drawings of a lock-gate at Clarendon, (France,) as illustrated by De Lagrené, in his "Cours de Navigation Interieure."

It is expected to fill and empty the locks by means of iron pipes in the side-walls, passing behind the hollow quoins, as well as by valves in the gates. It is estimated to fill a 15-foot lift-lock by the pipes alone in 12 minutes.

A method of maneuvering large lock-gates with certainty and celerity appears to be, as yet, undiscovered. The arrangements commonly in use are beams, or spars, for pushing shut or pulling open the gates, chains working over drums on the side-walls, two chains being required for each leaf, a toothed iron arc secured to upper part of gate at about one-quarter the width of the leaf from the "heel-post," and working into a corresponding arc imbedded in the side-wall, the arrangement being worked by crank and pinions; and finally, by a system of gearing worked from the top of the gate, actuating a wheel or roller traveling on a track on the floor of the gate-recess.

A necessary condition to the successful working of any of these plans requires that the roller-track near the outer end of the gate (which is common to all large lock-gate plans as a point of support, &c.) should remain unobstructed by deposits of sediment or *débris* of any kind. If this condition is maintained it would seem that the system of moving the gate by machinery attached to the outer end, and worked from the top of the gate itself, ought to be the more compact and effective mechanical arrangement for effecting the desired object.

The drawings show this method of working, as well as by a simple roller to be moved by either chains or booms. The booms are cumbersome and greatly in the way in a narrow valley like that of New River. The chains interfere with close joints of gate and miter sill, and are liable at any time to be effectually blocked by small chips or stones.

The short iron arc requires immense power to compensate for its want of leverage, and a long one would break of its own weight.

New River is not a sediment-bearing stream, and in it, if anywhere, it may be expected that a track on the lock-floor will remain unobstructed.

The toothed arc on the floor in this project is, for greater security, proposed to be raised above the floor on cast-iron brackets.

Dams.—The dams are proposed to be built of rubble-masonry, pointed off on exposed faces with a heavy stone coping, covered with timber. The estimates contemplate giving them a section of not less width than 10 feet, top or bottom, with a general thickness at bottom of about $\frac{7}{10}$ the height. The abutments are proposed to be of same character of work and material as the dams. The estimates also include for each dam the excavation of a trench 2 feet deep over the whole area of the foundation, and its filling with concrete; this, of course, will only be needed where the rock is seamed or imperfect. Five of the dams are located on rock of a slaty structure; the remainder on compact sandstone.

This division comprises 6 guard-locks and 51 lift-locks, of an average lift of 14¼ feet, and 33 dams having a mean length of 709¼ feet and a minimum length of 550 feet.

SYNOPSIS OF PROJECT AS NOW PRESENTED.

The locks are proposed to be made 250 feet by 48 feet in the chambers; canal prisms, where possible, 102 feet wide at water-line, and never less than 60 feet for very short distances.

Tunnels are proposed to be made 54 feet wide at water-surface, 9 feet deep below it, and 33 feet high above it.

Lock walls and gates are proposed to be arranged to permit navigation with $7\frac{1}{2}$ feet on a dam, 600 feet long, and are arranged to exclude floods of 100,000 cubic feet per second.

Commencing at lock in dam No. 32 of Greenbrier division, on the right bank of the Greenbrier, (to avoid flooding the Hinton bottoms, as would have been done by dam No. 1 of the survey of 1872,) a canal is traced 6,850 feet through the Hinton bottoms to lock No. 1, of 12 feet lift; thence the canal is continued 6,275 feet, partly in the river and partly over low points of bottom-land, to station 138, below the town of Hinton, where the line enters a pool 2,700 feet above dam No. 1.

Dam No. 1, 14 feet high and 1,010 feet long, is just above Tug Shoals; foundation on sandstone. Lock No 3, which is a guard-lock, is on left bank, and gives entrance to a canal around the shoals, 1,900 feet long, to locks Nos. 4 and 5, of 10 and 13 feet lift respectively, which lock into the pool from dam No. 2.

Dam No. 2, 11 feet high and 1,000 feet long, is at head of Brooks's Falls, 9,500 feet below lock No. 5; foundation, sandstone. Lock No. 6, of 11 feet lift, is located on the left bank, and locks into the pool formed by dam No. 3.

Dam No. 3, 16 feet high and 960 feet long, in two branches, is at Bragg's Island, 6,300 feet below lock No. 6; foundation on sandstone. Lock No. 7, of 9 feet lift, is on the right bank, and locks into pool formed by dam No. 4.

Dam No. 4, 12 feet high and 1,290 feet long, is located at Richmond's Falls, 12,100 feet below lock No. 7; the foundation is on hard conglomerate, with slaty lamina, to avoid the long section of canal on the left bank, as proposed at this place by Mr. Lorraine. It is now proposed to locate the locks (with intermediate basins) close to the right bank, cutting directly through the crest of the falls, and utilizing the deep pool above the debouche of Mr. Lorraine's canal. Lock No. 8, of 13 feet lift, is on the right bank at the dam. Lock No. 9, of 14 feet lift, is 300 feet below No. 8, and connected with it by a canal of that length. Lock No. 10, of 13 feet lift, locks into the pool formed by dam No. 5; it is connected with No. 9 by a basin 350 feet long.

Dam No. 5, 16 feet high and 770 feet long, is located 12,000 feet below lock No. 10; foundation, sandstone. Lock No. 11, of 12 feet lift, is on the left bank, and locks into pool formed by dam No. 6.

Dam No. 6, 15 feet high and 760 feet long, is located at head of Meadow Creek Bottom, 7,700 feet below lock No. 11; foundation, sandstone. Lock No. 12, on the right bank, is a guard-lock to enter a canal 2,100 feet long through the Meadow Creek Bottom. Lock No. 13, of 10 feet lift, is at lower end of canal, and locks into the pool formed by dam No. 7.

Dam No. 7, 16 feet high and 600 feet long, is located 6,200 feet below lock No. 13; foundation of slaty structure overlaying sandstone. Lock No. 14, of 15 feet lift, is on the left bank; connects by a cut 600 feet long with the pool formed by dam No. 8.

Dam No 8, 17 feet high and 1,640 feet long, is 10,100 feet below lock No. 14; foundation, sandstone. Lock No. 15, of 15 feet lift, is on the left bank, and locks into pool formed by dam No. 9.

Dam No. 9, 20 feet high and 820 feet long, is located at and above mouth of Glade Creek, 12,300 feet below lock No. 15; foundation in firm slate. Lock No. 16, of 12 feet lift, is on right bank, and connects with pool from dam No. 10.

Dam No. 10, 20 feet high and 600 feet long, is 7,800 feet below lock No. 16; foundation of sandstone and shale intermixed. Lock No. 17, of 13 feet lift, is on the rignt bank, and connects with pool from dam No. 11.

Dam No. 11, 22 feet high and 640 feet long, is 8,100 feet below lock No. 17, at the head of low bottom above Quinimont; foundation on hard shale. Lock No. 18, of 10 feet lift, is on right bank, and connects with a canal through low ground, 1,100 feet long, to lock No. 19 of 10 feet lift, which connects with pool from dam No. 12, giving entrance to Stretcher's Neck Tunnel, 11,400 feet below dam No. 12.

Dam No. 12, 27 feet high and 630 feet long, is located below Stretcher's Neck Tunnel, on a sandstone foundation. Its function being simply to back the water up to tunnel-entrance, no lock is provided for it; foundation, sandstone. Lock No. 20 is a guard-lock, located on the right bank, opening into approach-basin to Stretcher's Neck. Stretcher's Neck Tunnel is 1,320 feet between portals, and is followed by lock No. 21, of 19 feet lift, locking into a basin 310 feet long. Lock No. 22, of 18 feet lift, is at lower end of basin, and is immediately followed by lock No. 23, of 18 feet lift, which connects with the pool from dam No. 13.

Dam No. 13, 24 feet high and 600 feet long, is located 6,000 feet below lock No. 23, on firm red shale. Lock No. 24, of 10 feet lift, is on the right bank and connects with canal 550 feet long to lock No. 25, of 10 feet lift, connecting with pool from dam No. 14.

Dam No. 14, 12 feet high and 6.0 feet long, is located 6,950 feet below lock No. 25, on hard red sands one. Lock No. 26, on the right bank, is a guard-lock, giving entrance to a canal 1,000 feet long, extending to lock No. 27, of 12 feet lift, which connects with pool from dam No. 15.

Dam No. 15, 20 feet high and 600 feet long, is located 11,100 feet below lock No. 27,

just above Buffalo Shoals, on foundation of a slaty character, overlying sandstone. Lock No. 28, of 13 feet lift, on the left bank, is at the lower end of a canal 500 feet long, arranged to dispense with a guard-lock, and connect with pool from dam No. 16.

Dam No. 16, 18 feet high and 640 feet long, is located 6,500 feet below lock No. 28, on foundation of sandstone. Lock No. 29, of 15 feet lift, is on the right bank, and connects with the pool for dam No. 17 by a cut 600 feet long.

Dam No. 17, 31 feet high and 600 feet long, is located 10,200 feet below lock No. 29; a foundation of sandstone, alternating with hard slate. Lock No. 30, of 20 feet lift, on the left bank, connects with pool from dam No. 18 by a cut 1,500 feet long.

Dam No. 18, 30 feet high and 620 feet long, is located 13,500 feet below lock No. 30, near Arbuckle Creek; foundation, sandstone. Lock No. 31, of 22 feet lift, is on the right bank, and connects with pool from dam No. 19.

Dam No. 19, 21 feet high and 770 feet long, is located 16,700 feet below lock No. 31, on sandstone foundation. Lock No. 32, of 14 feet lift, is on the left bank, and connects with a canal 2,500 feet long, extending to lock No. 33, of 14 feet lift, which connects with the pool for dam No. 20.

Dam No. 20, 27 feet high and 690 feet long, is located 9,000 feet below lock No. 23, about one-half mile above Sewell, on sandstone. Lock No. 34, of 22 feet lift, is on the right bank, and connects with pool from dam No. 21 by a cut 1,000 feet long.

Dam No. 21, 31 feet high and 672 feet long, is located 12,800 feet below lock No. 34, on sandstone foundation. Lock No. 35, on the left bank, is a guard-lock, connecting with a canal 850 feet long, extending to lock No. 36, of 18 feet lift, which also connects with a canal 600 feet long, extending to lock No. 37, of 18 feet lift, which connects with pool from dam No. 22.

Dam No. 22, 42 feet high and 630 feet long, is located 4,900 feet below lock No. 37, on hard slate foundation. Lock No. 38, on the left bank, is a guard-lock, having an approach-cut 700 feet long above it, and connecting at lower end with a canal 500 feet long, extending to lock No. 39, of 17 feet lift, and lock No. 40, of 15 feet lift, which connects with pool from dam No. 23.

Dam No. 23, 23 feet high and 550 feet long, is located 3,700 feet below locks Nos. 39 and 40, on sandstone foundation. Lock No. 41, of 14 feet lift, is on the right bank, and connects with pool from dam No. 24.

Dam No. 24, 34 feet high and 600 feet long, is located 6,900 feet below lock No. 41, on sandstone foundation. Lock No. 42, of 19 feet lift, is on the right bank, and connects with a canal 900 feet long, extending to lock No. 43, of 19 feet lift, which connects with pool from dam No. 25.

Dam No. 25, 29 feet high and 600 feet long, is located 10,300 feet below lock No. 43: foundation, sandstone, overlaid in places with hard slate. Lock No. 44, of 20 feet lift, is on the right bank, and connects with pool from dam No. 26.

Dam No. 26, 35 feet high and 650 feet long, is located 7,800 feet below lock No. 44: foundation, sandstone. Lock No. 45, of 19 feet lift, is on the right bank, and connects with the pool from dam No. 27.

Dam No. 27, 16 feet high and 600 feet long, is located 5,200 feet below lock No. 45, one-half mile above Hawk's Nest; sandstone foundation. Lock No. 46, of 19 feet lift, is on the right bank, and connects with pool from dam No. 28.

Dam No. 28, 26 feet high and 600 feet long, is located 10,400 feet below lock No. 47: foundation on sandstone or hard conglomerate. Lock No. 48, of 13 feet lift, is on the right bank, and connects with a canal 1,000 feet long, extending to lock No. 49, of 13 feet lift, which connects with the pool from dam No. 29.

Dam No. 29, 32 feet high and 600 feet long, is located 5,600 feet below lock No. 49, below Cotton Hill Station; foundation, hard sandstone or conglomerate. Lock No. 50, of 20 feet lift, is on the left bank, and connects with the pool from dam No. 30.

Dam No. 30, 36 feet high and 660 feet long, is located 5,000 feet below lock No. 50, on sandstone foundation. Lock No. 52, of 13 feet lift, which connects with the pool from dam No. 31.

Dam No. 31, 39 feet high and 600 feet long, is located 4,800 feet below lock No. 52, just above the Blue Hole, on sandstone foundation. Locks Nos. 53 and 54, of 15 and 14 feet lifts, respectively, are on the right bank, and connect with the pool from dam No. 32.

Dam No. 32, 30 feet high and 800 feet long, is located at foot of Narrow Falls, on sandstone or conglomerate foundation, 10,000 feet below lock No. 54. Lock No. 55, of 21 feet lift, is on the left bank, and connects with the pool from dam No. 33. The approach to and pit for this lock are partially in solid-rock excavations.

Dam No. 33, 13 feet high and 1,400 feet long, is located just above the crest of Kanawha Falls, 10,200 feet below lock No 55, on foundation of sandstone conglomerate. Lock No. 56, of 15 feet lift, is on the left bank, and connects with a basin 250 feet long, extending to lock No. 57, of 15 feet lift, which connects with the pool below in the Kanawha River.

The total cost of the slack-water scheme, as shown by the appended estimates, in detail, will be—

With tunnel No. 2, Stretcher's Neck	$11,427,010
With tunnel 2, 4, and 5	14,162,617
And without any tunnels, about	11,000,000

The estimate No. 1, using only Stretcher's Neck tunnel, will probably be found the better line, as combining economy of time and cost.

RECONNAISSANCE OUTSIDE OF THE VALLEY OF NEW RIVER FOR TUNNEL-LINES, ETC.

Examinations were made as below for determining the practicability of avoiding some portions of the valley of New River by a resort to tunnels. Instrumental surveys were made by Big Loup and Meadow Creek, the differences by elevation in other cases being determined by aneroid barometers, (Casella's.)

No. 1. From near Alderson's Ferry, on the Greenbrier, by way of Griffith's and Lick Creeks, to New River.

No. 2. From the same point on the Greenbrier, by way of Little Meadow Creek, to New River.

No. 3. From mouth of Piney Creek, (Stretcher's Neck,) by way of Paint Creek, to Kanawha.

No. 4. From mouth of Piney Creek to Clear Fork of Coal River, and down Coal River to the Kanawha.

No. 5. From mouth of Arbuckle Creek to Big Loup Creek, and down that to the Kanawha.

No. 6. From Arbuckle Creek to Paint Creek, and down that to the Kanawha.

As none of these lines had any source of water-supply for a summit-level, tunnels were a necessity.

Line No. 1 would require a tunnel from 6 to 8 miles long.
Line No. 2, a tunnel 11½ miles long.
Line No. 3, a tunnel 13½ miles long.
Line No. 4, a tunnel 17 miles long.
Line No. 5, a tunnel 11 miles long.
Line No. 6, a tunnel 12 miles long.

These results were considered prohibitory, and further instrumental investigations were thought unnecessary. It is possible that lines Nos. 1 and 2 could be supplied with water by a reservoir on the site of that proposed by Mr. Ellet, on Meadow River, but at a very considerable increase of cost over the river-line, with very doubtful results as to economy of time.

Though the exhibit appears so unfavorable for any attempt to break away from the valley of New River with a water-line, I am inclined to the belief that the effort to accomplish the same object by a line of railway would show a more favorable result, especially for a narrow-gauge line.

The whole region of country about the head of Coal River and Loup and Paint Creeks, besides being a rich agricultural country in the valleys, has in its mountain-ranges large deposits of cannel and other coals which the configuration of the country will permit to be put cheaply and quickly in communication with the Kanawha River by means of tram-roads similar to those recently introduced into the mining regions of Spain, and advocated in Van Nostrand's Magazine, by Mr. Herman Haupt, civil engineer.

None of these streams, except Coal River, offer any possible facilities for water-transportation; the latter stream is now "slack-watered" to Peytona, and this work probably represents the ultimate capacity of the district in that respect.

In connection with the slack-water project, there is herewith submitted the report and estimates of Mr. J. M. Harris, superintendent James River and Kanawha Canal Company, to whom I am indebted for much valuable assistance during the progress of the surveys.

CANAL-SURVEY.

In order that the data procured in the field might enable any combination of canal and slack-water to be made hereafter, that may be considered desirable, independent of the views of those engaged in the field, two entirely distinct surveys were carried on, one all "slack-water," the other all "canal." For the canal an experimental line with cross-sections of the surface at every 100 feet was traced from the last dam of the Greenbrier division above Hinton to the pool above Kanawha Falls, a distance of about 60 miles.

The line was not prolonged beyond this point, for the reason that the New River for the 2 miles below to Kanawha Falls offers equal facilities for slack-water navigation

with the Kanawha below the falls, for which a modified form of that method of improvement has been definitely adopted. The location of the Chesapeake and Ohio Railroad on the right bank of the river from Hinton to Hawk's Nest, and on the left bank below that point to the falls, renders it generally a matter of necessity that a lateral canal should occupy the opposite bank of the river, as it is in only one or two places, and for short distances, that there is sufficient space between the road and the river for a canal even of much smaller section than that considered requisite for this line.

As traced and marked in the field, the line starts from the last dam on the Greenbrier, follows the right bank through the Hinton bottoms over the same route described for the "slack-water," crosses the river at the same point, and thence follows the left bank 9¼ miles, where it crosses the upper end of Meadow Creek bottoms on the right bank: passing through these bottoms for about 3 miles, it recrosses the river to the left bank, which it follows 13 miles to the upper side of Stretcher's Neck. Here the line crosses to the right bank, passes through the bend by means of a tunnel, and immediately recrosses to the left bank, which it follows 29 miles to a point just below the Hawk's Nest, where it crosses to the right bank, and occupies that side to the terminus below Narrow Falls, (about 2 miles above Kanawha Falls.)

From this brief description it will be seen that, as projected and traced in the field, the line crosses the river six times, viz, at Hinton Meadow Creek twice, Stretcher's Neck twice, and below Hawk's Nest. Of these, the crossing at Hinton is justified by the more favorable nature of the ground on the left bank, the railroad occupying the right bank; the crossings at Meadow Creek were made with a view of utilizing the favorable ground extending along the right bank for several miles between the railroad and the river, but after-study would indicate that for a really independent canal this line would be inadmissible, owing to the cost of aqueducts at the upper and lower crossings.

The canal-line, adhering to the left bank, between the crossing-points, would cost $768,300, and between the same points, by crossing, &c., as in the field, $800,335.25; so that without aqueducts, and with crossings in pools, nothing is gained by the crossing, and it is suggested that this crossing be abandoned. The crossings at Stretcher's Neck would probably have to be made, even though the line were continued around the bend, owing to the topographical features of the valley, and, as by a tunnel about 1,300 feet long a saving of distance of 3 miles is effected, the propriety of adhering to this arrangement seems evident. The crossing below Hawk's Nest is imperative, as the location of the railroad precludes the possibility of locating a canal along the left bank below this point. There will then remain four crossings of New River that may be considered as forming necessary features in the project, which may be possibly altered as to exact location, but yet will remain to be made somewhere along the line.

The method of crossing just below Hinton is in a measure fixed by the fact that the canal-bottom at that place could not readily be located high enough to enable an aqueduct to be used, which the great width of the river, moreover, would render very costly. It is therefore only proposed to cross at this place in a pool, using wire ropes with traveling-blocks for passing boats during freshets, or without steam-power. The other crossings can be made either by aqueducts or in pools, the former, of course, being the more expensive, yet it may be considered the only proper means to be used for a really independent canal.

The only motive for incurring the extra cost of constructing a canal where a slack-water navigation is practicable, would seem to be to secure certain immunity from the danger of interruption of the navigation by floods, and if the continuity of this protection is broken at several points, the canal, for all practical purposes, becomes nearly, if not quite, reduced to the same grade as the slack-water in this regard.

However this may be, estimates are submitted for making the crossings both by aqueduct and pools, except at the lower end of Stretcher's Neck tunnel, where the want of space for locks renders it practically essential to cross by aqueduct in order to overcome a portion of the lift on the left or opposite bank from the tunnel.

The crossing below Hawk's Nest, being in the gorge, it is suggested, also possesses claims in favor of the use of the aqueduct, arising from the declivity and contraction of the valley in that vicinity.

TUNNELS.

The same tunnel-lines described in the project for slack-water navigation have been connected with the canal survey and estimates of cost prepared for the different sections. The one similar to that proposed for the slack-water, which would permit boats to pass each other freely, is 54 feet wide at water-line. The other is similar to the section proposed for the summit tunnel, and is about 30 feet wide at water-surface. As all of these tunnels would undoubtedly (the rock being exposed along the river above and below their levels) be located in a compact sandstone, which would permit their easy excavation and maintenance with any desired width, the larger section would be well worth the extra cost over the smaller tunnel.

Assuming that the rate of travel in the tunnels would be one-half of that in the open canal, there would be no gain of time by the adoption of any of the tunnels, except that at Stretcher's Neck, where it might amount to forty minutes.

In regard to cost, tunnel No. 1, through the bend above Stretcher's Neck, including the aqueduct, to Stretcher's Neck, would cost about $1,600,000; and by canal and aqueduct, $1,300,000; or by canal crossing in pool, $700,000.

At this point, if the plan of crossing in all cases by aqueduct were adopted, questions of facility of operation, directness, &c., might justify the use of the tunnel; otherwise there can be no question as to the propriety of adhering to the river at a saving of nearly 40 per cent. in cost.

Tunnel No. 2, through Stretcher's Neck, (saving 3 miles by a tunnel 1,300 feet long,) appeared to be so evidently the proper line that the surveys were not carried around the bend.

Tunnel No. 3, about 4 miles below Stretcher's Neck, would cost about $1,260,000; and the canal around, $656,000, or about one-half the cost of the tunnel.

Tunnel No. 4, below Hawk's Nest, including aqueducts of approach in both cases, would cost about $1,555,500; and by canal around, $846,000, or a little more than one-half the cost of tunnel.

Tunnel No. 5, through the Blue Hole Bend, would cost about $1,330,000; and the canal around, $1,161,000; so that neither for economy of time nor money can any of the tunnel-lines, with the larger section of tunnel, be recommended, except No. 2 through Stretcher's Neck.

It is possible, however, that the inestimable difficulties of construction will justify the adoption of tunnel No. 5, as its cost is only slightly greater than the line around. Should the smaller section of tunnel be adopted, it would reduce the figures in the case of tunnel No. 1 by $460,000; No. 3 by $507,000; No. 4 by $369,000; No. 5, $554,000; which would make tunnels Nos. 3, 4, and 5 either equal to or less than the canal-line around in cost, and their adoption would therefore be justifiable.

In the appendix will be found a tabular statement showing distances by canal and by tunnels, and saving in distance and cost of each route.

AQUEDUCTS AND CULVERTS.

The aqueducts and culverts over 20 feet span are, with one or two exceptions, proposed to be built of wrought-iron trusses, carrying plate-iron troughs 30 feet wide in the clear. This plan was adopted on account of the difficulty of crossing either the river or its tributaries at a sufficient elevation above low-water surface to permit the discharge of flood-waters under masonry structures. It is proposed to convey feed-water over all the aqueducts in pipes, secured to the outer ends of floor-beams, in order that the levels may be kept full when the aqueducts are occupied by boats and others are being locked through at the lower end of the levels.

Owing to the very limited area of the water-shed of New River between the Greenbrier and Kanawha Falls, the number of tributaries of any considerable size is unusually small, and in consequence the number of large culverts is equally limited, there being (inclusive of Meadow Creek) only 7 over 20 feet span on the whole division 60 miles in length, and only 6 if the crossing at head of Meadow Creek Bottom be abandoned.

It is proposed to cross Meadow Glade and Loup Creeks by wrought-iron riveted trusses, of 66 feet, 158 feet, and 108 feet span, respectively, each carrying rectangular troughs of boiler-iron 30 feet wide in the clear.

At Mill, Arbuckle, Rush, and Wolf Creek, it is proposed to use masonry arches, single spans of 40 feet, 50 feet, 40 feet, and 100 feet respectively.

The aqueducts for river-crossings are three in number, all proposed to be wrought-iron Warren girders, carrying a similar plate-iron trunk to that described for the culverts.

Aqueduct No. 1, upper side of Stretcher's Neck, has 4 spans of 145 feet each.

No. 2, lower side of Stretcher's Neck, has 2 spans of 144 feet each.

No. 3, below Hawk's Nest, has, on the tunnel-line, 2 spans of 167 feet each, and on the line around the bend 3 spans of 167 feet each, and one of 100 feet.

Diagrams of these trusses, with a general section of water-trough, will be found with the drawings submitted.

LOCKS.

Investigation of the subject since the previous reports on this work were made tending to show that a change in the proportions of the lock-chamber might be desirable, they have been estimated for in this project as 4 feet wider than those formerly proposed, making them now 120 feet by 24 feet in the chamber.

Owing to the character of the country and the variable rates of fall in the river, it has been found difficult to establish or adhere to any uniform lift for the locks, though the endeavor has been made to introduce as few changes as possible, and to group the various lifts together in sections. In point of fact, the usual and ordinarily correct method has here been necessarily reversed, and the lifts of the locks increased as we descend the river; a matter of small moment in this case, however, as the river alongside will furnish always an abundant supply of water; and it is proposed to feed the levels by culverts or pipes passing around and outside of the locks. It was proposed to use 10 and 15 feet lifts as the standard, and of the 58 lift-locks, 19 are of 10 feet lift

and 27 of 15 feet lift; of the remaining twelve, seven have 12 feet lifts, one has 11 feet lift, three have 8 feet lift, and one has 7 feet lift. It is proposed to fill and empty the locks by means of culverts in the side-walls passing around the hollow quoins, as well as by slide-valves in the gates. The gates are proposed to be of wood, braced with iron; the masonry to be similar to that proposed for the Kanawha locks.

The division comprises 57 levels, their average length being a little over 1 mile: the longest is 20,000 feet and the shortest 400 feet.

CANAL-PRISM.

The section adopted for canal-prism is generally 74 feet at top, 60 feet at bottom, and 7 feet deep. River-side (or tow-path) bank, 10 feet on top; berme-bank, 8 feet on top; interior slopes, 1 to 1.

Through the Hinton bottoms the prism was estimated to be 102 feet wide, in order to render this section to some extent available as a transfer-basin for the trade that will at this point undoubtedly pass up and down New River, above the mouth of the Greenbrier. An estimate is also submitted for reducing the width through the gorge (from Sewell down) to 60 feet; but it would hardly appear that the economy ($500,000 in 17 miles) would balance the loss of capacity for transportation.

The surface of water in canal as located is generally kept well above the highest flood-marks, and where necessity compels any deviation from this rule, the river bank and wall is proposed to be raised to a sufficient height to prevent injury by floods.

The horizontal allignment has been made with a view of using no less radius of curvature than 1,000 feet. In a few places this has been reduced to 800 feet where the total angular change was slight, and in others the canal has been widened to form a basin in which the change of direction could readily be made.

The imperative necessity for preserving unobstructed the natural water-way of the river during floods, more especially in its lower portions, has precluded the extension of embankment-slopes into the river, and rendered necessary the frequent and continuous resort to retaining-walls, which will be found to form the main item of expense throughout the section.

The general character of about two-thirds of the excavations on this division would be classed as loose rock, the hill-sides being universally composed of broken fragments of all sizes thrown from the adjacent cliffs, and but slightly intermixed with soil or earth of any kind.

This material may naturally be expected to slide upon very slight provocation, and consequently, where deep excavations are required, the hill-slope must always be protected by a retaining-wall, which forms another large item in the estimates.

This same material will form the canal-prism throughout a large proportion of the whole line, (exactly how great a portion cannot be stated now,) and even with the liberal allowance of water to be had it will require some stanching to render it sufficiently water-tight for use. Whether any material which will prove effective for this purpose can be found on the highlands bounding the river valley, so as to be economically applied, cannot now be determined; the valley itself certainly offers no material in any considerable quantities at all suitable. The proportion of the line requiring it and the degree or amount of stanching being necessarily indeterminate, the estimates (to be on the safe side) contemplate for the *whole line* a continuous lining of the wetted perimeter of the canal-prism, with 6 inches thickness of concrete, costing $26,400 per mile.

It is altogether probable that one-third of this amount could be stricken off, and *possible* that it might be reduced to one-half of the whole length of the division.

In preparing estimates for walls, excavations, &c., the position of the rock-line was assumed from its position, where visible, its general trend, &c., and in all cases of doubt the assumptions were made certainly against the canal-line.

WATER SUPPLY AND FEEDERS.

The low-water discharge of New River is not accurately known; the lowest observed quantity that I am aware of was about 2,000 cubic feet per second. But the low-water discharge of the Kanawha River, which must be greater than that of New River alone, has been stated at 1,300 cubic feet per second, so that it would not be safe to estimate New River at over 800 cubic feet per second.

An amount, however, that it requires no lengthy calculation to show is an abundant supply for any trade that could be passed through the projected canal-locks.

It is proposed to feed the canal from the river at three points in the 60 miles, about equidistant from each other, making the length of canal to be supplied by each one about 20 miles.

Feeder No. 1 would be the pool in which the crossing is made from the Hinton bottoms, and is formed by slack-water dam No. 1.

Feeder No. 2 would be near Glade Creek, the pool being formed by a dam situated about half-way between dams Nos. 9 and 10 of the slack-water scheme. The length of feeder-drain is about 1,500 feet.

Feeder No. 3 would be below Arbuckle Creek. The reservoir is here formed by a dam

located the same as dam No. 18, (slack-water,) with some changes of dimensions, &c. The length of feeder-drain here required is 1,725 feet.

Each feeder, supposing the loss from all causes to be at the rate of 100 cubic feet per mile per minute, would be required to supply about 34 cubic feet per second. It is proposed to form the feeder-channel by first clearing away the loosest *débris* from the hill-sides, and then covering the area required with a coarse concrete, (afterward plastered,) upon which the sidewalks would be built, to form a rectangular water-way of the requisite dimensions.

It is believed that the masses of loose rock forming these slopes will afford a sufficently-firm foundation for such a structure, and the very great cost of excavating to solid rock will be avoided.

ESTIMATES.

The estimates show that for the whole line—

1. Using all the tunnels, 54 feet wide, and making all crossings of river by aqueduct, except at Hinton, (Meadow Creek crossing being abandoned,) the total cost would be	$21,255,590
2. Using 54-feet tunnels, 1, 2, 4, and 5, and aqueduct-crossings	20,650,895
3. Using 54-feet tunnels, 1 and 2, and aqueduct-crossings	19,762,498
4. Using 30-feet tunnels, 1, 2, 3, 4, and 5, and aqueduct-crossings	19,107,518
5. Using 54-feet tunnels, 2, 4, and 5, and crossing in pools	18,504,440
6. Using 54-feet tunnel, 2, and crossings in pools, (about)	17,600,000

Estimate No. 2, amounting to $20,650,895, is the arrangement I would recommend for an independent lateral canal, which could be reduced to $20,122,641 by making canal only 60 feet wide at water-surface from Sewell down.

Accompanying this will be found tabulated the following detailed estimates:

1. Fifty-seven sheets of estimates of 57 levels of canal-line.
2. Eight sheets of estimates on main and alternate canal-line.
3. Two sheets of estimates for feeders.
4. One sheet comparison of cost of tunnels of large and small section, (canal.)
5. Two sheets estimate of excavation below Sewell, if canal is made 60 feet wide.
6. Three sheets tabulated statement of cost of each level, accumulated totals, and other information relating thereto.
7. Thirty-four sheets of estimates of slack-water line.
8. Two sheets of estimates on main and alternate lines, (slack-water.)
9. One sheet table of aqueducts, giving location, dimensions, &c., (canal-line.)
10. One sheet comparative table of cost and distances by main and alternate lines.

Also, the following drawings:

1. Fourteen sheets general map of division, scale 200 feet to 1 inch, showing topography, &c., and location of canal and slack-water projects; canal in brown, slack-water in blue.
2. One sheet showing lines of exploration, (tracing.)
3. Four sheets of profile of canal-line, (tracings.)
4. Five sheets of profile of slack-water line, (tracings.)
5. One sheet general cross-section of large and small section of tunnel, (tracing.)
6. One sheet canal-lock drawings, (tracings.)
7. Two sheets slack-water-lock drawings, (tracings.)
8. Two sheets (cross-section paper) diagrams of aqueducts over Glade Meadow, Mill, Loup, Arbuckle, Rush, and Wolf Creeks, (canal-line.)
9. Nineteen sheets (cross-section paper) details of tunnel-lines and aqueducts across New River.
10. Seven hundred and forty-five sheets (cross-section paper) showing construction of canal-line.
11. Fourteen sheets (cross-section paper) with calculations of quantities and diagrams of 33 slack-water dams.
12. Eleven sheets (cross-section paper) with calculations of quantities and diagrams of slack-water canals and locks.
13. Fifteen sheets calculations and details of slack-water tunnels.

Note-books.

1. Five transit-books, (New River survey.)
2. Three topography books.
3. Eight level-books.
4. Seven cross-section books.
5. One sounding-book.
6. Also the following books, containing notes of reconnoissance of Loup Creek: one transit-book, one level-book, one barometric level.

Respectfully submitted.

N. H. HUTTON,
Assistant Engineer.

Col. WM. P. CRAIGHILL,
Major Corps of Engineers, U. S. A.

APPROXIMATE ESTIMATE OF EFFECT OF DAMS IN GORGE OF NEW RIVER, BETWEEN KEENEY'S AND NARROW FALLS.

For discharge over dams, Francis's formula is used, as being a mean of those of other observers:

$$R=3.33\ L\ (h)\ \tfrac{3}{2}.$$

The following assumptions are made, all of which are justified either by ascertained facts in the case of this river, conditions proposed to be obtained by the plans for this work, or experience on other rivers of somewhat similar characteristics:

1st. That the river falls about 1 foot in 300 feet.

2d. That the bed and valley of the river is cleared of all obstructions to a channel-way 280 feet wide at low-water surface, and side slopes not less than 1 to 1 for 30 feet above low-water level.

3d. That the dams are 600 feet long on comb and 30 feet above river-bottom.

4th. That at about the length of dam, behind or above it, the river-valley, at level of crest of dam, has at least a width of 400 feet.

5th. That the water in the pools will rise about 2 feet for every increase of 1 foot in depth above comb of dam and just behind it.

Dam 600 *feet long,* 30 *feet high; river above least width of* 400 *feet; river below least width of* 280 *feet.*

Depth on comb.	Discharge in cubic feet.	Area 600 feet below dam.	Area 600 feet above dam.	Velocity 600 feet below dam.	Velocity 600 feet above dam.	Remarks.
Feet.		*Sq. ft.*	*Sq. ft.*	*Ft. per sec.*	*Ft. per sec.*	
1	1,990	2,524	12,060	0.78	0.16	
2	5,640	3,096	12,524	1.82	0.45	
3	10,390	3,676	12,992	2.82	0.80	
4	13,850	4,264	13,464	3.24	1.02	
5	22,340	4,860	13,940	4.60	1.61	
6	29,370	5,464	14,420	5.37	2.03	
7	37,000	6,076	15,904	*6.00	2.33	*6 feet per second—4 miles per hour—limit of navigation.
8	45,210	6,696	15,392	6.75	2.94	
9	53,946	7,324	15,884	7.36	3.39	
10	63,270	7,960	16,380	8.00	3.86	
11	72,880	8,704	16,880	8.37	4.31	
12	83,000	9,256	17,384	9.00	4.77	
13	93,640	9,916	17,892	9.44	5.23	
14	104,630	10,584	18,404	10.00	†5.68	†Nearly 4 miles per hour above dam.

REPORT OF MR. J. M. HARRIS, ASSISTANT ENGINEER.

BALTIMORE, MD., *December* 9, 1874.

SIR: Herewith I submit to you the report of notes taken by me at your request, to arrive at an approximate estimate of the cost of removing the obstructions in the cañon of New River, so as to render its bed suitable for slack-water navigation.

These notes were commenced at a point about three miles below Bowyer's Ferry, where the canal terminates, after passing around Keeney's Falls. From this point downward the river in many places becomes very much contracted by immense bowlders of all shapes on its banks and in its bed. At other points bars have been formed by the creeks emptying material into the stream, also consisting of bowlders, and varying in size from many yards down to gravel.

The object of the estimate was to ascertain what it would cost to remove these obstructions to the natural flow of the stream, and thus cause the channel at low-water mark to be wider, to create a wider space above the bed of the stream for the water to escape in times of freshets, and thus render the bed of the stream safe for slack-water navigation. I deem it unnecessary to mention the method of arriving at quantities, as the note-books will fully explain, and about which you were consulted previous to entering on this duty. I will simply add that I have exercised the best judgment of which I was capable in making this estimate, and though much of the material was not actually measured, being inaccessible in a rapid river, yet, by comparing quantities which were actually measured with such of a similar character that could not be measured, I have arrived at an estimate which may be relied on as an approximation near the truth as to quantities. These quantities have been classified into two parts, the first composed of solid rock and large bowlders, requiring blast

ing. The second consisted of small bowlders, less than a cubic yard in size, loose rock and gravel. The first quantity I have found, agreeably to my estimate, to be 357,548¼ yards, and the latter 35,578 cubic yards. The former at 80 cents and the latter at 60 cents per yard, produce the sum of $307,385.80, the whole amount of the estimate.

You will understand that this estimate embraces all the material to be blasted or excavated from the banks and bed of New River, extending from Keeney's Falls to the Falls of Kanawha, as if there were to be slack-water throughout. But there will be several short sections of canal in this space. viz: 1,100 feet below dam No. 23, 2,500 feet below dam No. 24, and 3,700 feet below dam No. 29.

The amount estimated for improving the bed of the river corresponding to these spaces is $24,337.60, which, if deducted, would leave $283,048.20 as the estimate of clearing the river of obstructions, and if the tunnel commencing opposite Pope's Nose (railroad) tunnel, and terminating at or below the Blue Hole, is adopted, there would be another item of $45,888 to be deducted from the amount for clearing the bed of the river, leaving $237,160.20, or rather less than $15,000 per mile.

I deem it proper further to state that I estimated the width of the river at two or three of the narrowest points which could be found, with the view to ascertain what would be the narrowest point at low-water, when the bowlders and projecting points are cut off, agreeably to the plan proposed and embraced in this estimate. The narrowest point I found would be 265 feet at low-water when the obstructions are removed. The next narrowest point I found to be 277.7 feet when obstructions are removed. These points alluded to were between Cotton Hill and the Blue Hole, one at 3007+58, and the other at station 3063. At the former, the railroad was 64 feet from the edge of the river, but from the river's edge on the left bank the rock rises nearly perpendicular. There would be no difficulty in sloping the rock 1 to 1 by blasting off a portion of it, and the same slope or greater could be given on the opposite side, so that at a rise of 30 feet there would be at least an area of 9,000 square feet to pass the floods of New River.

The railroad-banks slope about 1¼ to 1 at the other point, and, though the low-water surface is narrower than at the upper point, there would be less trouble in giving enough space here to pass the floods of New River than at the upper point.

I saw no other points along New River where it seemed to be so much confined for want of space as at the points just named, and it was on this account I thought proper to ascertain its width, or at least what would be its width at low water, when the bed of the stream is prepared for slack-water navigation.

Respectfully submitted, by your obedient servant,

J. M. HARRIS,
Assistant Engineer.

N. H. HUTTON,
Assistant Engineer.

REPORT AND ESTIMATES ON THE IMPROVEMENT OF THE GREAT KANAWHA RIVER, BY MR. A. M. SCOTT, ASSISTANT ENGINEER.

CHARLESTON, W. VA., *January* 29, 1875.

COLONEL: I have the honor to submit the following report and estimates on the improvement of the Great Kanawha River:

Your instructions, dated August 17, 1874, and afterward somewhat modified, directed me to make such additional surveys as were necessary to enable estimates to be made, on the following plans of improving the river, so as to afford a *useful depth* of not less than 6½ feet, or an actual depth of 7 feet at all seasons:

1st. For a lock and dam improvement from the Great Falls to the foot of Paint Creek Shoal, and for sluice-navigation in the remainder of the river, assisted by a reservoir. This to be a revision of Mr. E. Lorraine's estimate, submitted to you in December, 1872.

2d. For a lock and dam improvement throughout, with locks about 250 by 50 feet in the chamber.

3d. For movable dams in the lower part of the river to accommodate the coal-trade, on the plan recommended for the Ohio.

I will briefly refer to previous surveys and the data at hand when your instructions were received.

SURVEY OF 1838,

made by Mr. Charles Ellet, jr., for the James River and Kanawha Company, and embracing the whole river from Great Falls to the mouth. The fall and distances, as established by it, have been proved very reliable.

SURVEY OF 1856–'57–'58,

made for the same company under directions of Mr. Lorraine, by Mr. John A. Byers It began at the head of Huddleston's Island, 6.80 miles below the falls, and extended

to the mouth of the river. This survey was without doubt very intelligently and carefully made, and from it we have a good hydrographic map of the river, except in some of the deep pools, where but few soundings were taken. The profile is continuous, and agrees closely with that of 1838.

GOVERNMENT SURVEYS.

First, a profile showing fall from Great Falls to the foot of Lykens' Shoal, from a survey made under your direction in 1872; second, special surveys made under Colonel Merrill, Corps of Engineers, in 1873. The latter embrace a little more than six miles of the river at different points where improvements have been proposed or carried on. These surveys tend to prove the reliability of the old maps and profiles.

To carry out your instructions it was necessary to make additional surveys at several points, particularly of localities where locks and dams were proposed, in order to select the sites as nearly as possible and make such examinations as were necessary to form an estimate.

Accordingly, a party was organized, and the survey began at the head of Loup Creek Shoal, 3.40 miles below the falls, on September 14, 1874. About six weeks were occupied in the field-work, surveys being made at sixteen different points. The soundings were all instrumentally located, and at each proposed site careful cross-sections run and drillings made to determine the necessary character of foundations.

During the first week of the survey the water fell to a point two-tenths of a foot below what has been considered ordinary low-water mark, and two parties were started to establish references at all desirable points along the river. This was fortunately accomplished before the water rose, and enabled us to reduce all work to a uniform and satisfactory reference. These bench-marks, and others made during the survey, were well established and described.

In connection with these surveys and the estimates and drawings presented, allow me to refer to the valuable assistance rendered by Mr. C. K. McDermott and Mr. John S. Hogue, civil engineers.

The general features of the river and the history and description of various plans that have been recommended for its improvement have been so fully presented in recent reports of the Chief of Engineers that nothing need be added here. Particular reference is made to your reports for 1871 and 1873, particularly to Mr. E. Lorraine's, accompanying the latter, (Appendix T 28,) and to Colonel Merrill's report for 1873, (Appendix M 3.)

The following table, showing the fall and distance from the Great Falls of places to be mentioned in this report, and of principal points along the river, may be useful:

Places.	Distance from Great Falls in miles.	Fall from Great Falls Basin in feet.	Length and fall of principal shoals, &c., in low water.
Foot of Great Falls	00.00	00.00	
Foot of Long Shoal	1.38	10.38	Shoal falls 10'.28 in 4,907 feet.
Foot of Loup Creek Shoal	4.71	22.15	Shoal falls 10'.12 in 8,736 feet.
Foot of Lykens' Shoal, town of Cannelton	9.19	32.10	Shoal falls 6'.19 in 2,250 feet.
Foot of Harvey's Shoal	10.61	36.99	Shoal falls 3'.98 in 1,400 feet.
Foot of Hunter's Shoal	11.28	38.09	Shoal falls 1'.60 in 950 feet.
Foot of Windsor Shoal	12.39	39.50	Shoal falls 0'.83 in 1,300 feet.
Foot of Paint Creek Shoal	15.12	45.70	Shoal falls 5'.12 in 2,300 feet.
Foot of Cabin Creek Shoal	20.83	53.21	Shoal falls 5'.15 in 2,376 feet.
Foot of Witcher's Creek Shoal	23.94	57.48	Shoal falls 3'.70 in 2,500 feet.
Foot of Cat-fish Shoal, head of Charleston Pool, near Brownstown.	26.49	60.29	Shoal falls 1'.53 in 1,400 feet.
City of Charleston, near foot of Charles' Pool	36.82	60.76	Pool 10.65 miles long, fall 0'.47.
Foot of Elk Shoal	37.46	63.47	Shoal falls 2'.71 in 1,700 feet.
Foot of Two-Mile Shoal	39.33	66.55	Shoal falls 2'.79 in 1,900 feet.
Foot of Island Shoal	40.05	68.85	Shoal falls 2'.21 in 1,900 feet.
Foot of Tyler Shoal	41.62	72.93	Shoal falls 4'.10 in 5,700 feet.
Foot of New Comer Shoal	43.52	74.96	Shoal falls 0'.59 in 500 feet.
Foot of Johnson Shoal	53.03	83.03	Shoal falls 4'.35 in 5,600 feet.
Foot of Tacket Shoal	55.81	86.11	Shoal falls 2'.20 in 2,904 feet.
Foot of Red-House Shoal	62.14	89.86	Shoal falls 2'.84 in 1,850 feet.
Foot of Gillespie's Ripple	67.25	93.67	Ripple falls 0'.90 in 2,200 feet.
Foot of Knob Shoal	71.78	97.17	Shoal falls 2'.60 in 3,200 feet.
Foot of Buffalo Shoal	73.10	98.54	Shoal falls 0'.90 in 1,000 feet.
Foot of Five Ripples—Ripple, Debby, Intermediate, Eighteen-Mile, and Ripple.	76.34	102.25	Total fall 2'.80 in 12,100 feet.
Foot of Arbuckle Shoal	79.20	105.02	Shoal falls 2'.03 in 3,300 feet.
Foot of Thirteen-Mile Shoal	82.63	106.77	Shoal falls 0'.86 in 1,300 feet.
Foot of Three-Mile or Cantrell's Bar	92.40	107.70	
Point Pleasant, mouth of Kanawha	94.20	107.92	

PLAN FOR SLUICE NAVIGATION BELOW PAINT CREEK.

It appears to be conceded that a lock and dam improvement is advisable for the first fifteen miles from the Great Falls—that is, to the foot of Paint Creek Shoal—and there is but one other plan to be compared with the same system in the remainder of the river. This is the combination of Fisk and Ellet's plans for sluice navigation, as suggested by Mr. Lorraine. As explained in his report referred to, it consists in making the best possible use of all the water in low stages, by "grading the river" with an elaborate system of sluice-dams and supplying the deficiency from a reservoir.

Ordinary brush and pile dams were proposed, filled in with stone and gravel, and the tops well secured by a frame-work of square timber. They were to be built square across the river, with a waterway or sluice 120 feet wide on top and 94 feet at bottom; the bottom of the sluice to be a strong crib filled and backed up with loose stone. The top of each crib was to be placed 6 inches below the one next above, consequently requiring a dam for every 6 inches of fall in the river. Mr. Lorraine states that this must be made a matter of experiment, and thinks it might be practicable to reduce the number of dams by increasing the fall from one to another to 9 and perhaps to 12 inches. His estimate, however, was based upon a 6-inch fall, necessitating 120 dams below the foot of Paint Creek shoal. They were to be so located as to reduce the slope on the worst shoals to 2 feet per mile. With this arrangement, and the ordinary low-water discharge taken at 1,350 cubic feet per second, there would be a theoretical depth of about 3 feet and 10 inches in the sluices. To fill the waterways and make 7 feet depth, 1,970 feet additional, or a total of 3,320 cubic feet per second, would be required. This result, which is considerably larger, proportionally, than given by Mr. Lorraine, was obtained by assuming a uniform channel of the dimensions proposed for the sluices, with a slope of 2 feet per mile, and using the formula.

$$V=\sqrt{8975.41\ \frac{a-s}{P}}-.10889.$$

If the discharge of the waterway is considered as from one reservoir to another, with a head of 6 inches, a liberal calculation gives nearly the same result as above. Besides the water required to fill the sluices, about 200 cubic feet per second would be needed to keep the dams submerged, making a total of 2,170 cubic feet per second, or 187,488,000 per day, to be furnished by the reservoir. The annual available contents of the Meadow River reservoir, according to the final estimate of Mr. Ellet, would be 10,722,032,640 cubic feet. This, divided by 187,488,000, gives over 57, the number of days the reservoir would be able to maintain 7 feet navigation, when the discharge of the river was reduced to 1,350 feet per second.

We have but little reliable data to determine how much help the river would probably need, there having been no regular gauge observations taken previous to August 1, 1872. The following table is made from a reliable record, and compared as near as possible to the references used by Mr. Ellet:

	Water down to 0.0, or ordinary low mark.	Below + 0′.5.	Below + 1′.0.	Below + 1′.5.	Below + 2′.0.
	Days.	*Days.*	*Days.*	*Days.*	*Days.*
After August 1, 1872	18	36	56	75	91
Entire season of 1873	00	6	28	44	65
Entire season of 1874	7	21	54	90	115

Both 1872 and 1874 were considered low-water seasons. The discharge, computed by Mr. Ellet from observations taken just below the foot of Elk Shoal, was, for + 2′.07, 8,550 cubic feet per second. We have nothing very reliable from which to determine it between +2′.07 and low water, but it will be safe to consider it for +1′.5 to be 3,520 cubic feet, the liberal estimate of quantity required to fill the sluices and keep the dams submerged.

The "low-water season" has been taken at sixty days, in previous reports, and the record since August 1, 1872, as well as general information to be had, goes to prove this a safe assumption, and that a reservoir able to keep up the supply during fifty-seven days, of what can safely be called the minimum discharge, would be ample for any reasonable emergency.

ESTIMATE OF COST.

As stated, this plan contemplates locks and dams down to the foot of Paint Creek Shoal. The details for this part of the estimate will be given under that for slackwater throughout. The table submitted, showing dimensions, costs, &c., of each sluice-dam, is, as near as possible, a revision of Mr. Lorraine's, increased to afford seven feet of

water. Owing to the nature of the plan, this can be considered but an approximation. Care has been taken, however, to make it large enough, and it is thought sufficient to cover all contingencies. The following is a summary for the complete improvement:

For four stone locks and dams above Paint Creek Shoal, locks 280 by 50 feet in the chamber	$918,041 00
For excavations of channels and approaches to locks	95,000 00
Total to foot of Paint Creek Shoal	1,013,041 00
For 120 sluice-dams below Paint Creek Shoal	490,216 00
For protection of banks below Paint Creek Shoal	48,000 00
For excavation of channels below Paint Creek Shoal	52,200 00
Lorraine's revised estimate for Meadow River reservoir	533,200 00
	2,136,657 00
Add 10 per cent	213,665 00
Total estimate	2,350,322 00

IMPROVEMENT BY LOCKS AND DAMS THROUGHOUT.

Under this head your instructions direct two estimates, one for an ordinary slack-water improvement, the other for a modification of this well-known system in the lower part of the river by movable dams, on the plan proposed for the Ohio. That for the common improvement will be given first.

The general character of the surveys made in September and October, 1874, under your direction, has been explained. As stated, they were mostly directed to making approximate locations and thorough surveys at the proposed sites for locks and dams. The relative arrangement as to location, lift of locks, &c., will be given in a table with a summary of the estimate.

SIZE OF LOCKS.

You gave me some latitude by directing the estimate to be made for locks *about* 250 by 50 feet in the chamber. The large-sized coal-barges are from 120 to 130 feet long, and generally 24 feet wide. To accommodate this important interest the locks should have at least an *available* length of about 250 feet. They were finally planned and estimated at 280 feet between quoins, and a clear width of 50 feet in the chamber. This gives an available length of 245 feet for the full width of the lock. I think this still too short, and that they should be built to afford a clear length of 260 feet, or nearly 300 between quoins. The additional length of chamber would add but little to the cost and materially increase the capacity of the locks, as they would nicely admit four barges of the size which experience has proved to be the most economical for the shipment of coal, (130 by 24 feet,) or three barges and a small tow-boat.

CHARACTER AND DESCRIPTION OF MASONRY.

As directed, the estimate was made for stone locks, dams, and abutments of the best kind of hydraulic masonry; the general design of the locks to be similar to the last built on the Monongahela River by the navigation company, and one now in progress by the Government, at Hoard's Rock, under Colonel Merrill. The water is admitted through the upper platform and an arched miter-wall, and discharged through the lower gates. The masonry was estimated rather heavier than that in the Monongahela locks; the river and shore walls of the chamber respectively at 8 and 6 feet wide on top, with an outside batter of about 1 in 6. Around the gates and abreast of recesses these dimensions were about doubled. The dams were planned with a width at base of not less than 10 feet, or seven-tenths the height; 9 feet wide on top, and capped with a sloping course of timber and plank, well fastened to the masonry. Abutments to be carried up 15 feet above the crests of the dams, 6 feet wide on top, with a double batter of 1 in 12; total length of face and wings averaging about 120 feet. The estimate includes substantial guide-cribs and ice-breakers above, and dry retaining-walls below the locks, and a liberal allowance for paving and riprapping the banks at least 300 feet below the works.

FOUNDATIONS.

Considerable time and labor were spent to determine their necessary character. As shown by the following table, solid rock can be obtained at seven of the sites, and it is thought can be found at others, by more thorough examination, without materially changing the locations selected. At the remaining five sites, foundations of piles and timber are proposed, substantially like those adopted for the Illinois River locks, at Henry and Copperas Creeks. The first was built a few years ago, and the latter is now in progress, under direction of Colonel Macomb, Corps of Engineers.

Below each dam not on solid rock, a very strong pile and timber apron is proposed,

extending 20 feet below the dam. The plan of foundations and apron will be shown on the general drawings to accompany this report.

The detailed estimates for this improvement were forwarded to you on the 9th instant. A summary is given in the following table, with location, lift of lock, length of dams, &c.:

Number from Great Falls.	Location.	Distance from Great Falls.	Distance from mouth of river.	Lift of lock.	Length of dam	Character of foundation.	Estimated cost.
		Miles.	*Miles.*	*Feet.*	*Feet.*		
1	Near head of Loup Creek Shoal	3.34	90.86	9.6	660	Rock	$174,931
2	Near foot of Loup Creek Shoal	4.67	89.53	10.4	785	Rock	213,105
3	Foot of Lykens Shoals, at Cannelton	9.19	85.01	13	676	Artificial	272,459
4	Foot of Paint Creek Shoal	15.12	79.08	13	579	Artificial	257,546
5	Brownstown, near head of Charleston Pool	26.84	67.36	13	548	Rock	219,940
6	First below Charleston Pool, head of Island Shoal.	39.69	54.51	7	544	Artificial	218,573
7	Near head of Newcomer Shoal	43.22	50.98	6.5	563	Artificial	220,142
8	Between Scary and Johnson Shoals	52.46	41.74	7	598	Rock	182,644
9	Head of Red House Shoal	61.77	32.43	6.5	670	Rock	191,067
10	Near foot of Gillespie's Ripple	67.36	26.84	6	590	Rock	164,187
11	Head of Debby's Ripple	75.02	19.18	7	558	Rock	170,340
12	Foot of Three-Mile or Cantrell's Bar	92.40	1.80	8.7	697	Artificial	244,442
	Total for locks and dams						2,529,376
	Estimate for excavation of channels and approaches to locks						268,000
							2,797,376
	Add 10 per cent. for contingencies						279,737
	Total estimate						3,077,113

IMPROVEMENT BY MOVABLE DAMS, AS PROPOSED FOR THE OHIO RIVER.

For a description of these dams, it is only necessary to refer to the elaborate report of the Board of Engineers on Movable Dams, &c., consisting of General Weitzel and Colonel Merrill, (Ex. Doc. No. 127, H. of R., 43d Congress, 1st session,) and to Colonel Merrill's annual report, printed as Appendix N of the Report of the Chief of Engineers for 1874. As shown in these reports, this modification of the common slack-water plan is designed particularly to accommodate the coal-trade, and you directed me to extend the estimate for it as high up the river as this interest seemed to require. In view of the importance of this interest and the great advantages of movable dams to suit it, it was thought advisable, in planning for the ordinary improvement, to do so with reference to their final adoption below Charleston. Accordingly the maximum lift for the locks in this part of the river was taken, as by Colonel Merril for the Ohio, at 7 feet. This would virtually extend the movable system to Brownstown, at the head of the Charleston Pool, and though the coal-field extends still higher, the arrangement it is thought would accommodate the whole interest very well, as there would be at most but two lockages to get the coal into the Charleston Pool, where there would be every facility for harboring it and for making up tows. If it should ever be found desirable to extend the movable dams as high up as Cannelton, at the foot of Lykens Shoal, it could be done by building two intermediate locks and dividing the lifts of Nos. 5 and 6.

This arrangement makes the number of locks the same as proposed by Mr. Lorraine in his report to you, and also as recommended by Mr. John A. Byers in 1868, when he made a general estimate for a lock and dam improvement below Loup Creek. It adds one to the number of locks below Charleston, however, and reduces the number above to five. The advisability of the high dams proposed at Paint Creek and Brownstown, particularly at the latter place, is somewhat questionable, but they are no higher than some on the Monongahela River, where the height of banks and general characteristics are similar, and as the arrangement is quite desirable I conclude, to recommend them.

In the table the lift of lock No. 12 is given at 8'.70; this is with reference to present low-water at the mouth of the river. It will finally depend on the connection made with the lock and dam system projected on the Ohio. Colonel Merrill informed me that he could give no definite information about it, but thought there would be no difficulty in adopting their plan to suit any arrangement on the Kanawha. The low-water surface at the mouth can easily be raised enough to reduce the lift of No. 12 to 7 feet; and if it should prove expedient to raise it about 3½ feet, the first lock on Ka-

nawha can be located at the foot of Thirteen-Mile Shoal, where rock-foundation can be had.

A summary of the estimate for the complete improvement by movable dams below and permanent dams above Charleston, with locks 280 by 50 feet, is submitted. That for the movable dams is based on the price per linear foot taken by Colonel Merrill for the Ohio, (Appendix N, Report of the Chief of Engineers for 1874.) The details are given in the same (N 9) in Lieut. F. A. Mahan's report on the Youghiogheny River.

The width of "pass" proposed for the Ohio has also been adopted, as it has been found necessary to make the present towing channels on Kanawha about 250 feet wide, to answer the requirements of the coal-trade.

Number of dam from Great Falls.	Number of dam from Charleston.	Location of dams.	Distance from Great Falls in miles.	Length of pass in feet.	Cost per linear foot.	Estimate for pass.	Length of weir in feet.	Cost per linear foot.	Estimate for weir.	Total length of dams.	Total cost.
6	1	Head of Island Shoal	39.69	250	$344	$86,000	294	$227	$66,738	544	$152,738
7	2	Near head of New Comer Shoal	43.22	250	344	86,000	313	227	71,051	563	157,051
8	3	Between Seary and Johnson's Shoal	52.46	250	344	86,000	348	227	78,996	598	164,996
9	4	Head of Red-House Shoal	61.77	250	344	86,000	420	227	95,340	670	181,340
10	5	Near foot of Gillespie's Ripple	67.36	250	344	86,000	340	227	77,180	590	163,180
11	6	Head of Debby's Ripple	75.02	250	344	86,000	308	227	69,916	558	155,916
12	7	Foot of Three-Mile Bar	92.40	250	344	86,000	447	227	101,469	697	187,469
						602,000			560,690		
		Total for movable dams									1,162,690
		Locks and abutments, as shown in estimate for slack-water throughout									971,496
		Total cost of movable-dam improvement below Charleston									2,134,186
		Estimate for five locks and permanent dams above Charleston Pool									1,137,981
		Estimate for excavation of channels and approaches to locks									268,000
											3,540,167
		Add 10 per cent. for contingencies									354,016
		Total estimate									3,894,183

In regard to the relative merits of the two plans of improvement, (not to consider the movable dams,) I believe the slack-water can be much more confidently recommended. There are elements of uncertainty connected with the plan for open navigation; and it is thought, with every condition realized, it would have no advantages over locks and dams. The sluices are not more than half wide enough to answer the requirements of open navigation, and it appears they cannot be made much wider than planned, (120 and 94 feet,) if dependence is based on the one reservoir. This is about the width of the present "dug chutes" on the river, and, in stages when the navigation is confined to them, experience has limited descending tows to two and never more than three loaded barges. The great difficulty anticipated, however, is to ascending craft. No form of sluice can obviate the unpleasant currents to be encountered in entering and passing them, and in the night or windy weather, particularly in certain stages of water, this would be rendered more or less dangerous.

Mr. W. R. Hutton, in his report to you dated January, 1871, alludes to the resistance to a tow of loaded boats passing the sluices up-stream, and says they would necessitate some modification of the present system of towing. If the tows should be limited to the size that could enter the locks proposed, (three barges and a tug) it is thought 120 sluices would cause much more trouble and delay than the eight locks proposed in the same distance. In addition to these objections, and the uncertainties of realizing every condition of a theoretical plan, there is an element of danger connected with a reservoir of the dimensions proposed, formed by a dam nearly 70 feet high, which should not be ignored.

From past reports it appears that a plan of open improvement has been sought for two principal reasons, one being the local objection to slack-water improvement, the other the incidental assistance which the reservoir would render to the Ohio. I think it may be said that neither of these reasons now demand consideration, for the people of Kanawha are almost without exception in favor of locks and dams, and it is generally conceded that the same system, or some modification of it, must be resorted to on the Ohio. Pains have been taken to learn the sentiment of river-men, who are

generally familiar with this plan from observation of the Monongahela slack-water, and they are found universally anxious to have it adopted on the Kanawha.

If the movable dams, so confidently and ably recommended for the Ohio, should prove successful, they would remove almost every possible objection to the slack-water improvement.

Very respectfully, your obedient servant,

A. M. SCOTT,
Assistant Engineer.

Col. W. P. CRAIGHILL,
Major Corps of Engineers, U. S. A.

REPORT ON IMPROVEMENT OF GREAT KANAWHA RIVER BY MEANS OF LOCKS AND DAMS, BY MR. WM. R. HUTTON.

BALTIMORE, MD., *June* 30, 1876.

SIR: The project for the permanent improvement of the Kanawha River as recommended by the Board of Engineers on the 25th of May, 1875, (see page 94, part 2, Report of Chief of Engineers for 1875,) has for its object to furnish a navigable depth of 7 feet at all seasons of the year, from the mouth of the river to the falls. It proposes to accomplish this by means of nine locks of low lift, with movable dams, from the mouth to the foot of Paint Creek Shoal, which is 15 miles below the falls, these 15 miles being improved by three locks of 15 feet lift each, connected with permanent dams.

The project is based upon the very complete surveys made in 1858 by Mr. John A. Byers, and special preliminary surveys of the different sites selected for permanent works made under your direction by Mr. A. M. Scott in 1873, 1874, and 1875.

In 1873 the low-water surface of each pool was observed, and referred to a proper permanent bench-mark, the surface of Charleston Pool reading 1.50 on the gauge-board at that place. This has been adopted as standard low water, although in 1874 the surface of the pool was 0.2 foot lower. In 1875, an accurate survey was made from Cabin Creek Shoal to a point 2¼ miles below Brownstown, and a line of careful levels was run from the Falls to Newcomer's Shoal, 7 miles below Charleston.

The only recorded gauges of the discharge of the river made before last year were those of Mr. Ellet. During 1875, twelve gaugings were made by Mr. Scott at the site of lock No. 5, 8¼ miles above Charleston, at various stages, ranging from 1.55 feet to 32 feet above low-water. The river was very full during the entire season, and at no time did it fall to low-water mark.

The river is fully described, as to its general characteristics, by Mr. Lorraine, in his report to you of December 9, 1872, (see page 836, Report of Chief of Engineers for 1873.). I recapitulate the principal features. The length from the Falls to the Ohio River is 94 miles; total fall from the pool at the foot of the Great Falls is 108 feet, 47 feet of which occurs in the first 15 miles. The average width is 590 feet. During low water it is navigable from the upper end of Charleston Pool to the mouth by steamers drawing 3 feet. Above Charleston Pool, there is no navigation at low stages, although some improvements have been made in the way of sluices and training-walls, which are valuable to navigation at moderate stages. Coal is not shipped, however, until the river rises 5 or 6 feet at Charleston.

Ordinary floods rise to 25 or 30 feet above low water in the upper half of the river, which here does not overflow the general level of its banks. The highest flood on record, that of 1861, rose to 47 feet.

Extreme low-water discharge, according to Mr. Ellet, is 1,100 cubic feet per second; ordinary low water, about 1,300 cubic feet. Comparing the Kanawha with the Seine, which has been improved with movable dams, the low-water discharge of the Seine is 1,700 cubic feet per second, that of the Kanawha being 1,350 (rarely 1,100) cubic feet. The maximum flood of the Seine (anno 1658) rose 29.3 feet; of the Kanawha, 47 feet in September, 1861, at Charleston above (0) of gauge, which is 45¼ above low water. Ordinary high floods of the Seine 20.5 feet, with a discharge of 56,000 cubic feet; of the Kanawha, 36 feet, discharging probably 132,000 feet. The low-water slope of the Seine above Paris is 0.5 foot per mile; of the Kanawha below Paint Creek, 0.8 foot per mile.

Although the Kanawha is not navigable at low stages, there is no flood in which boats do not run. In this it differs from the Seine, where navigation ceases when the flood exceeds 10 or 12 feet.

As has been already mentioned, the project for the improvement embraces the construction of nine locks with movable dams, and three locks with permanent dams. The greater slope above the foot of Paint Creek Shoal renders it inexpedient to continue the improvement by movable dams above that point.

The movable dam, which has led to the recent great development of the interior

navigation of France, is fully described and figured in the report of Weitzel and Merrill, upon "Hydraulic Gates and Dams," (see page 688, part 1, Report of Chief of Engineers for 1875.) Its object is to permit an open river navigation whenever the natural depth of the water is sufficient, and to furnish a navigation by locks and dams during low stages of the river. The navigation pass or sluice, in the present project 250 feet in width, is an opening in the dam, with its sill about the level of the bottom of the river. It is furnished with wickets, which may be raised to close it to the full height of the dam, and which lie flat upon the floor when the pass is open. The fixed portion of the dam is usually provided with wickets of a less height, to regulate the water in the pool, and to facilitate opening and closing the wickets of the pass. Their use is not contemplated in the original project, but further study indicates the substantial advantages which would follow their introduction.

Good river navigation above Charleston requires at least a stage of 6 feet on Charleston gauge. With this height there is a rise of about 5.5 feet at lock No. 5; so that with the sill of the pass placed one foot above bottom, we have 8.5 feet of water in the pass. With 6 feet on Charleston gauge, the discharge of the river is about 12,000 cubic feet, giving a velocity in the pass of about 4.5, or a height on the dam, if closed, of 3.06 feet. As the water rises, we have, with a depth of 10 feet in the pass, a velocity of 4.8 feet; with 12 feet, 5.8 feet per second; and when the pass is full, but none discharging over the weir, (supposed without wickets,) 6.4 feet, or about 4½ miles per hour, the lock-gates also being open for the passage of the stream. To diminish these velocities, as well as to reduce the maximum height of the sheet flowing over the wickets of the pass, which will permit a reduction of their strength and weight, the dam might be finished at 4 feet below the level of the pool, and furnished with wickets of that height. These will be comparatively inexpensive; being low, they may be wide, say 6 feet at least, and they will need no slide or tripping-bar. Reference is intended to the wickets of the Chanoine system, which should be preferred on account of their cheapness. The Desfontaines system is more convenient, but the first cost is much greater.

The surveys of the past season have enabled definite locations to be made for locks and dams Nos. 4 and 5, the former at the foot of Cabin Creek Shoal, and the latter about a mile below Brownstown, near the head of Charleston Pool. Lands have been purchased at both sites, and both locks are under contract, as well as the dam at No. 5.

The surveys have also developed the fact that the river-bed is underlaid at no great depth by a ledge of rocks lying nearly parallel to the general slope of the river. Its continuity is not perfect; but it is so general that we may reasonably expect to find suitable locations for all the works, where they may be founded upon the rock.

The levels that have been taken show the changes that have occurred in the height of surface of the pools in the past twenty years. The improvement of the bars by increasing the water-way through them, increasing their depth, at the same time lowers the surface of the pool above it. Thus, Charleston Pool has been lowered nearly 2 feet by the great improvements to the channel at Elk Shoal; and the same effect is observed at other points.

As a type of the low lock and movable dam, a description is introduced of No. 5, at Brownstown, some eight miles above Charleston, now under construction. The lock, which is 364 feet in total length, 300 feet between hollow quoins, and 50 feet in clear width, is designed to pass at one lockage four coal-barges of the dimensions usual on the Ohio and Kanawha Rivers; that is, 130 feet long, 24 feet wide, and drawing 6 feet of water. It is placed in the river as near to its left bank as practicable, while giving a good entrance and exit for boats. The dam, about 560 feet long, crosses the river at right angles to its direction, opposite the lower abutment, with a height from the rock of about 17 feet, and will raise the water nearly 11 feet above low water. The pass adjoins the lock, is 250 feet wide, and its floor is 50 feet long in the direction of the stream. The pier which separates the pass from the river is 13.5 feet wide, 48 feet long, and 4 feet higher than the dam. The right bank of the river is protected by a masonry abutment rising 10 feet above the dam, with wings extending to the top of the bank, above the reach of overflow.

The lock-walls will rest upon the rock, which at this point is between 3 and 4 feet lower than the miter-sills. At the ends (the abutments for the gates) they will have a thickness of 16 feet; the interior faces will batter one-fourth of an inch to the foot; the exterior faces will be vertical on the river side, while the backs of the shore-wall will batter 2 inches to the foot. Between the ends or abutments, the chamber-walls are 12 feet thick at bottom of lock and 5 feet at top, the whole height being 20 feet, depth of water 7 feet, and lift of the lock 7 feet. The top of the lock is therefore 6 feet above the top of the dam.

The upper and lower miter-sills are placed at the same level, so that, by opening all the gates, the lock may serve as an extension of the pass. The miter-sills are of stone faced with timber; the floor of the lock is of concrete covered with plank, except a space below each gate, which is paved with dressed stone. The angles, hollow-quoins, miter-sills, coping, &c., are of cut stone; the rest of the masonry will be of a much cheaper class, although not inferior in fitness, strength, and durability; all to be laid

in the best manner in hydraulic cement. The chamber-walls will be furnished with rings for the purpose of securing boats. The locks will be filled and emptied through valves in the gates, in addition to iron culvert-pipes passing around the hollow quoins. It is proposed to build the gates of iron frames, covered with a sheathing of plank.

In the lower abutment on the river-side is a well containing the gearing for tripping or throwing down the wickets of the navigation pass. This, as well as the chain wells and gearing for operating the gates, is contained below the surface of the coping and covered by iron plates; for, as the lock will be submerged in floods, it is necessary that no machinery or framing should be exposed on top of the walls.

The floor of the pass is about 3 feet above the rock foundation. It is formed of concrete, supported front and rear by timbers framed into crib-work; the top is furnished with large timbers arranged to hold the journals, slides, &c., which are attached to them, and paved between the timbers with stone.

The wicket is a wooden frame 13 feet 6 inches high and 3 feet 8 inches wide, covered with planks, and capable of revolving about an axis placed at the middle of its height. This axis is formed by the cross-head of an iron frame or horse, which is itself movable about a horizontal axis fixed upon the floor.

When a wicket is raised, its foot rests against the sill of the floor; its horse is maintained vertical by an iron prop, the foot of which abuts against a heurter, an iron abutting piece fastened to the floor.

The wickets, being placed side by side across the current, form when raised a dam to close the pass. A movable foot-bridge is constructed up-stream, across the pass, to facilitate the operations of opening. To throw down or open a wicket, it is necessary to pull sidewise the foot of the prop, so that it shall slide across and clear of the foot of the heurter. The prop, having lost it support, slides upon the floor down-stream; the horse at the same time turns about its axis and falls upon the floor; the wicket follows them, and covers and protects the other pieces.

If there were no water upon the floor, the wicket would be broken by the fall, but a very shallow cushion of water is sufficient, in a great measure, to destroy the shock.

The foot of the prop is pulled away from the heurter by means of the tripping-bar, one end of which carries a rack, gearing into a pinion in the well in the lock-wall, worked by a crank on top.

To raise the wicket, the lock-keeper stands upon the foot-bridge, and by means of a portable winch pulls up a chain attached to the foot of the wicket. The wicket rises, maintaining, however, a position nearly horizontal. It offers, therefore, but little resistance to the current. The horse and the prop follow its ascent until the foot of the latter, passing over the inclined plane, which forms the top of the heurter, falls in front of it, at the same time that the horse attains a vertical position; the axis of the wicket is now in its final position, and a slight push on the foot of it, or even the slacking of the chain, is enough to cause it to right itself and bear its foot against the sill.

The three upper locks will be connected with fixed or permanent dams, and will be founded upon the rock. The upper miter-sills will rest upon breast-walls, through which the filling-culverts will discharge. The dams will be of masonry, with aprons of crib-work filled with concrete to protect from scour the soft rock of the foundation. The head-walls of the lock will be carried up to a sufficient height to permit their being used in moderate floods.

The locks, with movable dams, will generally be founded upon the rock. They have no breast-walls, but both ends of the lock are upon the same level, so that it may be used for purposes of navigation when the pass is open. The walls extend but 6 feet above the dam, and will be submerged in floods.

When rock foundations cannot be obtained at moderate depths, both lock and dam will be built upon piles. The floor of the lock will be an inverted arch to withstand the upward pressure of the water; the floor of the pass will be a heavy bed of concrete on piling, and filtration will be prevented by rows of sheet-piling and cross-walls of concrete.

The cost of completing the improvement on the present plan is estimated, after careful revision, at $4,132,500. But it is proper to add that the work now under contract has been let at prices very much below those used in the estimate.

Respectfully,

Wm. R. HUTTON.

Col. WM. P. CRAIGHILL,
Major of Engineers, U. S. A.

COMMUNICATION TO THE PITTSBURGH COMMERCIAL RELATIVE TO THE OHIO RIVER IMPROVEMENT.

To the Editor of the Pittsburgh Commercial:

Great public improvements are rarely accomplished without violent opposition, and strange as it may seem, the most strenuous opponents are usually those who in the end

derive the greatest benefit from the measures they oppose. When agricultural implements began to be introduced, farm laborers, led by farmers, destroyed the machines and held public meetings to denounce whoever favored their introduction. Planing-mills were opposed by the torch of the incendiary. Canals, when projected, have been denounced by wagoners, and railroads, in their turn, by the canal-men and their associated interests. Railroads have been threatened with annihilation lest they might destroy the market for horse-feed, or carry fright and death among the farmers' herds.

It is not to be supposed that the obstructives and croakers in such cases are consciously instigated by bad motives; on the contrary, a majority of them sincerely believe their rights and living endangered. In most cases they are blinded by the extravagant declamations of a few over-confident and mistaken leaders, whose wild assertions and groundless predictions they mistake for facts and arguments.

THE MONONGAHELA NAVIGATION

was built in the face of bitter opposition from the flatboat-men and farmers along shore. "It is a remarkable fact," says one of the early reports, "that with so many unanswerable arguments to recommend it to and enforce it upon the public attention, no work in the country has ever encountered greater obstacles than this. Instead of being, as it ought to have been, fostered by our citizens, and hailed by the Monongahela Valley as a blessing to themselves, it met with nothing but the most chilling regards from the one or the most determined hostility from the other."

It was declared that the obstructions and tolls would extinguish

THE COAL-TRADE

and destroy the value of coal-lands, and insufferable delays and expenses caused by the locks would ruin the river for steamers. As the result of the improvement the coal-trade has increased since its construction from 400,000 bushels to 63,707,500 bushels, and the increased value of the lands has been many times more than the entire cost of improvement. As to delays to steamers on account of the locks, Capt. E. Bennett, the most experienced boatman on the river said, "The time of running the fifty-five miles, including the passing of the four locks, varies from five and one-quarter to six hours (9 to 10½ miles an hour, including the delays,) by different boats," not including stoppages for freight and passengers.

* * * * * * *

"I do not recollect coming up from Pittsburgh to Brownsville before the completion of the slack-water in less than twelve hours, and frequently from twenty to twenty-four." The uniform depth and the absence of current far more than compensate for the delays of the locks.

COLONEL MERRILL'S PLAN.

The plan for the improvement of the Ohio is the result of 30 years' additional study and experience of the best engineers of the world, and is infinitely superior to the Monongahela navigation; nevertheless, opposition is the fate of every improvement and must be encountered and overcome by this one also.

We could hardly expect the owners of an $80,000 tow-boat to be pleased at first blush with an improvement which will enable a $4,000 or $5,000 tug with its barges by running safely all the year round, carrying coal down and freight up, to be a successful competitor, and this is one of the results anticipated from the improvement.

A memorial to Congress, which I have seen to-day, states that only one interest of the vast commerce of the Ohio is opposed to the improvement, and that only in part. Having knowledge that some of the parties are in opposition only from a misunderstanding of the subject, let me endeavor to describe the plans and manner of working as they present themselves to my mind, and their effect upon navigation.

1. A lock is to be erected on one side of the river, the outer wall of which will be 770 feet long, parallel with the current, and forming one side of the navigation-pass.

2. Opposite to the middle of the lock, extending out from the other side of the river, is a permanent dam or weir of a proper height, which reaches a point 400 feet from the wall, leaving a channel or navigation-pass between the dam and the wall 400 feet wide and as deep as the present river-bed.

3. The navigation-pass has a system of gates or wickets capable of being raised so as to close it when it becomes necessary to convert the navigation into slack-water.

4. In order that the permanent part of the dam may make the least possible obstruction to the water in times of unusual floods, and that it may be used in regulating the depth in the navigable pass, it is made very low and capable of being increased in height when needed by a similar arrangement of wickets.

Thus in all high and moderate stages of water there will be a clear unobstructed channel 400 feet wide. When the water has fallen below the minimum depth fixed upon for the navigation—say 6 feet—the wickets in the pass will be raised, and there will be until the next rise a slack-water navigation in the river.

The locks will be 630 by 78 feet inside, and will pass ten coal-barges, with large tow-boat and fuel flat, at one lockage.

This method has been in successful operation

ON THE SEINE

and other French rivers for years without any serious accident or failure. There are navigation-passes on the Seine 230 feet wide and locks 615 by 40 feet. The barges on the Seine are about the size of those on the Ohio, though the fleets are somewhat smaller. The Ohio being a larger stream, bearing larger fleets, the navigable passes and locks are correspondingly enlarged; and this being the only difference from the plan in successful operation, to assert that "it will not work" is simply a waste of words.

The width of the open navigable pass is only 120 feet less than that of the pass now being constructed at the mouth of the Mississippi River, and is 100 feet wider than the channel between the piers of the Steubenville bridge. It is 320 feet wider than an average coal-fleet, nearly 300 feet wider than the widest and nearly double the width of the present wing-dam channels which they will supersede.

The operation of this

SYSTEM UPON THE OHIO

will not only leave the river free for the present method of navigation upon floods, but it will increase the length of time during which the flood will be available. This I will explain as well as I can in the absence of drawings.

On the French rivers when the water is high

THE NAVIGABLE PASS

is open and all the wickets on the low part of the permanent dam are down. When the water falls to the minimum depth required for the navigation there is still several feet running over the low permanent dam or weir, and the lockmen then begin to raise the wickets on the weir at the shore end. Each day they raise whatever number may be necessary to turn the additional amount of water into the navigable pass which may be needed to keep up the required depth. When all the water of the river is thus made to go through the pass, and it still continues to fall, they begin to close the main wickets day by day as fast as is necessary to keep up the depth in the navigable pass by *contracting the width*. Thus they keep open the gap, gradually narrowing its limits, as long as it can be run with safety to the works; then close it, and use the locks during the continuance of low water. Let us see how this would affect the Ohio. I have before me, in the engineer's report for 1871, a table showing the

DAILY STAGE OF THE WATER

by the Pittsburgh gauge for the year 1868, about an average year. From this it appears that there was—

8 feet and over, 65 days in the year.
6 feet and over, 153 days in the year.
Between 5 and 6 feet, 44 days in the year.
Between 4 and 5 feet, 31 days in the year.
Under 8 feet, 300 days.
Under 6 feet, 212 days.
Under 5 feet, 168 days.

It must be evident to even a casual observer of the Ohio that, if the quantity of water which flows in the open river to make a 6-foot stage could be concentrated into a pass only 400 feet wide, it would increase the depth in the pass to an amount proportionate to its volume and velocity. So also the water which makes a 5-foot stage in the open river.

Applying this plain fact, we find that if by raising the wickets on the permanent part of the dam during a 6-foot stage and turning all the water into the navigable pass, and the depth of the pass would be increased only 2 feet, there would be 8 feet in the channel for 153 *days instead of* 65 *days, as now*. If concentrating the water when there is 5 to 6 feet would raise it in the pass from 1 inch to 1 foot, we would have an open 6-foot navigation 197 days instead of 153 as now.

By raising half the wickets in the navigable pass and reducing the width 200 feet as the water begins to sink to the 4-foot stage, the 6-foot open navigation could probably be continued 31 days longer, increasing the 197 days to 228 days, and leaving but 137 days during which the locks would be necessary for navigation. Thus we would get an

improvement from the navigable passes and dams alone, even without the locks, represented by the following figures:

	Unimproved river. Days.	Navigable pass. Days.
Depth, 8 feet and over	65	153
Depth, 6 feet and over	153	197
By narrowing the pass		228

To make these figures mathematically correct would require intricate calculations and measurements involving velocity, currents, &c., but they are accurate enough for illustration, and approach very near to what will be realized from the proposed method of improvement.

They show that the Ohio can have a practically unobstructed channel for navigation 6 feet deep and over for 228 days in the year, and slack-water with convenient and capacious locks the remainder of the time, during the greater part of which it is now unnavigable.

F. R. B.

PITTSBURGH, *February* 19, 1876.

REPORT ON THE SURVEY OF THE SUMMIT-LEVEL, BY MR. E. LORRAINE, PRINCIPAL ASSISTANT ENGINEER OF THE JAMES RIVER AND KANAWHA CANAL.

RICHMOND, *January* 20, 1852.

SIR: I have the honor to submit to you the following report of the survey of the summit-level of the James River and Kanawha Canal, made under your instructions dated April 7, 1851, and in accordance with subsequent instructions received from time to time in the field and by correspondence.

The object of the survey was to ascertain the practicability and cost of supplying with water the summit level of the canal. A survey for this purpose was made in the year 1827 by Capt. William G. McNeill, of the United States Topographical Engineers, by whom it was pronounced practicable to feed from the Greenbrier. As his plan, however, involved the adoption of a tunnel five miles long through the Greenbrier Mountain, it was deemed expedient to make a further examination of the Greenbrier and its tributaries to ascertain whether it was practicable to feed from the Greenbrier and at the same time dispense with the long tunnel.

The survey was commenced at the eastern base of the Alleghany Mountain, where it was connected with station 1093, the terminating point of a survey of the line of canal from Covington westward, made under your direction by John E. Mills, esq., in the fall of 1850. Having established the summit-level, as directed by you, at an elevation of 696 feet above the level of Jackson's River at Covington, and 1,916 feet above tide, a location was made for the tunnel through the Alleghany to the point where the plane of the summit-level intersects the western base of the mountain, in the valley of Tuckahoe Creek. From this point I traced a line for a feeder along the eastern side of the South and Middle Forks of Howard's Creek, crossing over the Middle Fork to the North Fork; then crossing the North Fork and running down its western margin along the base of Greenbrier Mountain, and around the south point of that mountain to the eastern side of the Greenbrier River, and thence up the Greenbrier. This line was traced with great care for about nineteen miles up Greenbrier River, when the impracticability of feeding from Greenbrier by drawing the water from any pond that might be formed upon this level became so evident, for reasons that will be hereafter stated, that, after advisement with you, the location of the feeder-line was abandoned. The levels and compass-line, however, were continued up that river to the Droop Mountain or the mouth of Spice Run, a distance of fifty-six miles from the summit-level, and about forty miles up the Greenbrier from the mouth of Howard's Creek.

The Greenbrier River is bordered by mountains which generally slope down to the water's edge, with occasionally a narrow strip of low grounds intervening between the base of the mountain and the river. The sides of the mountain have a general inclination of from 25° to 35°, and not unfrequently of 45°. From Greenbrier Bridge for 19 miles up the river they are covered with loose rock, in many places perfectly bare of soil, and from 6 to 10 feet deep, measuring vertically. A feeder-canal constructed in such a locality would require very high walls on one side, for which it would be difficult to procure a substantial foundation, and on the other side, in order to obtain a sufficient slope, a great extent of the surface of the hill would have to be removed. The whole of the bottom and the sides up to the water-line would have to be lined with puddle, which could only be procured from a great distance, and generally from the opposite side of the river, and hauled up a steep hill, upon an average of 150 feet above the river: and then after the feeder was constructed, in the most substantial manner, it would be liable to be swept away by slides of earth, stones, and

trees, brought down from above by every heavy rain that occurred. The entire length of the feeder would be about 53 miles, which might be shortened to 31 miles by the adoption of Captain McNeill's 5-mile tunnel or to 43 miles by the adoption of a tunnel 2¼ miles long through the Greenbrier Mountain, opposite the White Sulphur Springs. With either of these tunnels the general character of the feeder would be, as above described, difficult to be made substantial, and extremely costly. Those are the considerations which led to an abandonment of the plan of supplying the summit-level by means of a feeder from the Greenbrier.

Having concluded the survey of the Greenbrier, my attention was directed, by particular instructions from you, to the other streams which are so abundant in that mountain region, with a view of testing their availableness as feeders. The most prominent of these are Anthony's Creek, Little Creek, the Middle and North Forks of Howard's Creek, and the South Fork of Howard's Creek, or Tuckahoe Creek. The first in rank of these streams is Anthony's Creek, which is a tributary of the Greenbrier. It is 25 miles long from its mouth to its source, and is fed by Little Creek, and three principal branches which unite about 15 miles from its mouth, and also innumerable smaller streams and springs which issue from the sides of the mountains by which it is bound.

About 8 miles above its mouth there is a place called the "Narrows," where the creek has forced its way through a steep and narrow gorge of the mountain, and above which the mountains diverge, and the stream runs through a beautiful valley about a half-mile wide. This place was selected as a site for a mound, which, when thrown across this narrow point, will effectually arrest the water that flows down the creek, and convert the valley above into a magnificent reservoir 9 miles long and 46 miles around, with an average width of one-half of a mile, a superficial area of 2,753 acres, and a mean depth of 60 feet. The mound for this reservoir will be 126 feet high and 395 feet long. In order to avail ourselves of this immense body of water, it will be necessary that the mountain-ridge which separates the southern border of the reservoir from the valley of Howard's Creek shall be pierced by a tunnel 2¼ miles long. The level of the bottom of this tunnel will be 30 feet below the surface of the water in the reservoir. It passes for its entire length through a black-slate rock of easy excavation, and as it will only be necessary to be made just large enough to be advantageously worked, it cannot be considered an obstacle of any serious importance. After passing through this tunnel, the water from the reservoir will flow down the bed of Dry Creek, and at the narrow gorge where it enters into the valley of the North Fork of Howard's Creek, a dam 300 feet long and 20 feet high will have to be constructed to stop the water and turn it by a tunnel 200 yards long into the valley of the Middle Fork of Howard's Creek, after which it will be conducted by a feeder canal 2.8 of a mile long, of a cheap and easy construction, to the summit-level.

In the valley of Little Creek, there will also be a reservoir, the water from which will be conducted by a feeder of 4.3 miles long into the Anthony Creek reservoir. The mound of this reservoir will be 690 feet long and 40 feet high. The area of the reservoir will be 127 acres, and the depth of available water 20 feet.

Upon the north or main fork of Howard's Creek there will be two reservoirs; the lower one of which is called the Howard's Creek reservoir, will be made by a mound, 1,180 feet long and 50 feet high. Its area will be 156 acres, and depth of available water 25 feet. The upper one is called the Jericho reservoir, the mound for which will be 222 feet long and 63 feet high, its area 92 acres, and mean depth 21 feet; all the water of which can be drawn off into the lower reservoir whenever it may be required. The water from these two reservoirs will be conducted by a feeder-canal, 1,800 feet long, into the pond formed by the dam across Dry Creek, where it will connect with the water from Anthony's Creek.

The fifth and last reservoir is that upon Tuckahoe Creek. This reservoir is formed by a mound 589 feet long and 85 feet high; its area is 159 acres, and mean depth of available water 30 feet. The localities of these reservoirs and feeders will be more fully understood by reference to the accompanying map.

Under the mounds of all the reservoirs adequate provision has been made, conformable with your direction, for culverts which will allow the waters of the creeks to pass off during the construction of the mounds, and obviate all annoyances and danger to the work in time of freshets. After the reservoirs are filled, these culverts, with the appendages of pipes and gates, will be used for drawing off the water as required, for the purpose of feeding the canal, or for drawing it all off, if necessary, for repairs.

Having given the above brief description of the general plan of the reservoirs, the next thing to be considered is the

SUPPLY OF WATER.

In conformity with the principles laid down by you, I shall first enter into a calculation of the supply of water which will be required for the use of the canal, and then into a calculation of the supply that will be afforded by the reservoirs.

The whole length of the canal to be supplied entirely by the reservoirs would be that

portion between the point on the eastern side of the summit where Dunlap's Creek is taken in as a feeder, and the point on the western side of the summit where Howard's Creek is taken in as a feeder, a distance of about 9 miles. But as the supply from Howard's Creek will be considerably diminished by the quantity of water which will be shut off by the reservoir above, we will not consider Howard's Creek as affording any supply at all, except what is obtained from its reservoirs. It should, however, be borne in mind that this will be a most liberal deduction from our actual supply, especially during the winter months, when this creek is full, and would be a most important auxiliary. The length of canal then which we will assume as supplied by the reservoirs is all that portion included between the point where Dunlap's Creek is taken in and the Greenbrier River, a distance of $15\frac{66}{100}$ miles. After the prism of the canal shall have been filled, the yearly supply which will be demanded from the reservoirs will be a quantity sufficient to supply the loss by leakage through the locks and evaporation and filtration from the canal, and the quantity consumed in the passage of the boats through the locks of the summit-level.

From experiments made by Mr. Fisk on the Chesapeake and Ohio Canal, the loss by leakage through the locks, which are of the same size as ours, amounted to 62 cubic feet per minute, and the monthly loss upon the same canal from evaporation and filtration was about twice the quantity of water contained in it. The whole quantity, then, lost upon our canal would be, according to Mr. Fisk's experiments, 59 cubic feet per minute for each mile. According to Mr. Jervis's experiments on the Erie Canal, the total loss from evaporation, filtration, and leakage through the gates is about 100 cubic feet per minute for each mile. Let us, then, assume the highest of these quantities as our standard. The portion of the canal occupied by the tunnel and its approaches being through solid rock, would be subjected to no leakage, and not as much loss by evaporation as would be supplied by subterranean springs, and is, therefore, excluded from this calculation, leaving the entire length of the canal subject to filtration and evaporation $11\frac{8}{10}$ miles. The loss, then, by leakage, filtration, and evaporation would be 1,180 cubic feet per minute, or 1,699,200 cubic feet per diem.

In making the estimate for the quantity of water consumed in passing the boats through the locks, let us assume that the canal shall enjoy a full trade, and the boats pass through the locks at the summit as fast as possible. The average time of a boat passing a lock of 10 feet lift is about 6 minutes, or about 240 boats per diem. Assuming a full trade, we must also assume a fair alternation of boats passing the summit-level, which would allow $1\frac{1}{2}$ prisms of lift to each boat, or 360 locks full of water per diem, which, for locks of 10-feet lift, would amount to 5,400,000 cubic feet per diem. Add to this quantity 1,699,200 cubic feet, the quantity lost by leakage, filtration, and evaporation, and we have 7,099,200 cubic feet, or 262,933 cubic yards, per diem as the quantity of water necessary to navigate the canal with a full trade.

To arrive at the amount of water that will be available to supply the above demand, we must estimate the quantity that will be supplied by the rain falling upon the area of country drained by the several streams upon which the reservoirs are to be constructed. For this purpose rain-gauges have been kept at points bordering upon the said streams, and the results of observations of four consecutive years have been recorded. An accurate survey of the area of the country drained was made under my direction during the last summer, in which the whole outline of the basin of each stream extending along the top ridges of the Alleghany and its spurs was carefully traced. From the above data the average quantity of rain which falls per annum can be easily obtained; and after making the proper deduction for evaporation and absorption, we arrive at the quantity of available water which the streams afford. But as this supply is not constant, but variable, it is necessary that it should be regulated. For this purpose mounds must be constructed at convenient points across these streams, which will dam them up and form large reservoirs, from which the supply requisite for the navigation of the canal can be drawn off at pleasure. To ascertain the quantity of water which these reservoirs will contain, an accurate survey was made of their superficial extent, after which cross-sections of their depth were taken at every considerable variation in the ground with the angles of the hill-side at every station of 100 feet. Each reservoir was then divided into a number of fields, the superficial and cubic contents of which were separately calculated.

The area of the country drained into these respective streams is as follows:

	Acres
Into Anthony's Creek	65,160
Into Little Creek	5,634
Into Howard's Creek	20,196
Into Tuckahoe Creek	9,522
Total	100,512

or 157 square miles.

The result of the rain-gauges at Anthony's Creek is an average of 37 inches per annum, and at the White Sulphur Springs 35 inches per annum, giving a general average

of 37½ inches, which, falling upon the above area, will give 506,848,833 cubic yards per annum, or 1,388,627 cubic yards per diem. The annual drainage from a given area depends upon the climate and the topographical and geological features of the country. From extensive experiments made by Mr. Charles Ellet, jr., upon the Ohio River, which are recorded in his "Physical Geography of the Mississippi Valley," he has ascertained that the annual drainage in that section of country is 40 per cent. of the rain that falls. In other localities it is found to be 50, and as much as 60 per cent. The country surrounding the summit-level of the James River and Kanawha Canal is all mountainous. The sides of the mountains are generally steep and but scantily covered with soil, offering every facility for a rapid discharge of the water which falls upon its surface. When we take into consideration the difference between this country and that which is drained by the Ohio River, the latter consisting principally of gentle slopes, we are warranted in the conclusion that its annual drainage must be by far the greater of the two, and even greater than any of the above estimates.

From observations made by Mr. J. B. Jervis, in reference to the reservoirs for the Chenango Canal in the State of New York, it appears that, in that locality, about two fifths (or 40 per cent.) of the quantity of rain may be collected for the supply of a reservoir. We will put it, therefore, at the low estimate of 40 per cent., which will leave 555,450 cubic yards per diem as its drainage, and the quantity that may be collected in reservoirs, or more than twice as much as would be required for the navigation of the canal. By a proper distribution of reservoirs nearly the whole of this quantity of water might be collected and retained for future use. But, as all of it would not be required, it is only proposed to construct a few reservoirs in the most advantageous localities, where narrow passages through the mountains suddenly expand into spacious valleys, and where short and high mounds thrown up at no great expense, across the narrow gorges, will shut up large bodies of water, which can be drawn off and used at pleasure.

The following table will show the area and cubic contents of these reservoirs, and the annual drainage into each of them:

Reservoirs.	Area of reservoir in acres.	Cubic yards available water in reservoirs.	Area of drainage in acres.	Cubic yards of rain per annum for depth of 37 inches.	Forty per cent. of rain allowed for drainage.
Anthony's Creek	2,753	109,189,130	65,100	324,099,758	129,639,903
Little Creek	127	3,013,856	5,654	28,122,468	11,248,987
Howard's and Jericho	248	9,276,410	6,751	33,573,870	13,429,548
Tuckahoe	159	7,693,464	9,522	47,361,539	18,944,616
Total	3,287	129,172,860	87,086	433,157,635	173,263,054

From an inspection of the above table, it will be seen that the quantity of water assumed to be available, and proposed to be reserved for the use of the canal, is 173,263,054 cubic yards per annum. From this quantity should be deducted the annual loss from evaporation and leakage of the reservoirs and feeders. We will put down the annual evaporation from the reservoirs at Smeaton's estimate of 36 inches; but 60 per cent. of the annual fall of rain, or 22 inches, having been already allowed to pass off by evaporation and absorption, in which the rain falling upon the surface of the reservoirs is included, only the difference between that quantity and 36 inches, or 14 inches, should be allowed for evaporation. The allowance for leakage and absorption in the reservoirs should be limited to the quantity of leakage through the mounds. There can be no leakage or absorption or filtration in the reservoirs themselves, for after the water has passed through and saturated the thin overlying stratum of soil, it would reach the impenetrable rock, and then it would have to stop; there could be no further absorption or filtration.

We will then only consider the leakage through the mounds, and for this purpose we will suppose each mound to be the bank of a canal of 30 feet bottom, and that the contents of such a canal would pass through its banks once in fifteen days, or as there would be but one bank, once in a month such an allowance for all the reservoirs would be equal to 40 inches of their surface annually, which, added to 14 inches, gives 54 inches as the whole deduction for evaporation and filtration in the reservoirs, equal to 23,863,620 cubic yards per annum. For evaporation and filtration in the feeders, allow that each feeder will lose the whole of its prism of water once in every fifteen days. This for

7½ miles of feeder, with an area of cross-section of 58.50 square feet, will amount to 2,051,200 cubic yards per annum. We have then for deduction:

	Cubic yards.
For evaporation and filtration in the reservoirs	23,863,620
For evaporation and filtration in feeders	2,051,200
Total	25,914,820
Which deducted from total supply	173,263,054
Leaves for available water, per annum	147,348,234
Or, per diem	403,694
The quantity estimated as required being, per diem	262,933
We have a surplus of water, per diem, over demand, equal to	140,761

In making the above calculations, we have exact data for the area of drainage and the downfall of rain. The allowances made for the drainage and for losses by evaporation and filtration in the canal, reservoirs, and feeders, are based upon careful observations and experiments made by distinguished engineers in this country and in England. In adopting this basis, however, it will be observed that we have not availed ourselves of the highest or lowest estimates which would best suit our purpose, or even of an average, but have been contented to assume the lowest for the amount of drainage, and the highest for the evaporation, filtration, and leakage. Still we have the large surplus of 140,761 cubic yards per diem, or more than one-half of the required supply. This surplus is amply sufficient to cover any contingencies or objections that ingenuity may suggest. To cover the ground, however, more fully, it is a fact worthy of attention that we have not in the above estimate availed ourselves of the whole area of drainage, but that there still remains 13,446 acres of drainage on the middle fork of Howard's Creek, which might be added to the above estimate, and that by multiplying the reservoirs in the valleys of the streams embraced in the survey, a sufficient supply of water could be obtained for nearly two such canals.

If, at some future time, the increase of trade on the canal should demand a double set of locks, and consequently nearly a double supply of water, the additional quantity that might be demanded could be obtained in the mode above indicated. Dunlap's and Potts's Creeks on the eastern side of the mountain could also be taken in, if necessary.

Below is an estimate of the cost of supplying the summit-level:

Anthony's Creek mound	$166,181 [illegible]
Anthony's Creek feeder-tunnel	318,509 [illegible]
Little Creek mound	17,056 [illegible]
Little Creek feeder	43,996 [illegible]
Jericho mound	15,030 [illegible]
Howard's Creek mound	47,554 [illegible]
Howard's Creek feeder	5,799 [illegible]
Dry Creek mound	2,435 [illegible]
Feeder from Dry Creek to Summit, including tunnel	52,382 [illegible]
Tuckahoe mound	83,348 [illegible]
Land-damages	51,000 [illegible]
	803,292 [illegible]
Add for contingencies 20 per cent	160,658 [illegible]
Total cost	963,950 [illegible]

The above estimate includes all the reservoirs and feeders that may be necessary for the navigation of the canal with a full trade, and is intended to cover all contingencies. But as the canal at first would not have a full trade, and would probably not be open on an average for more than eleven months in the year, thereby diminishing the required supply of water one-twelfth, it is evident that there would be no necessity for constructing all these reservoirs at first. Anthony's Creek reservoir would of itself be amply sufficient to supply the canal during the whole year—for many years to come. A strict estimate of the cost of supplying the summit-level should then be confined to the cost of that reservoir and its feeders, which will amount (with 20 per cent. added for contingencies) to $696,963.

Daily gauges of Anthony's Creek were commenced last August, and will be continued until twelve months shall have expired. These gauges, together with the rain-gauges, will furnish us with exact data, by which we can ascertain the annual discharge of water by the creek, the difference between which and the downfall of rain will show the quantity carried off by evaporation and absorption.

Toward the close of the survey I was joined by Professor Tuomey, of the University of Alabama, who was invited by the President to make a geological examination of

the sites of the reservoirs. That gentleman made a laborious and careful examination of the whole ground, the results of which have been published, and are highly satisfactory.

Very respectfully, your obedient servant,

E. LORRAINE,
Principal Assistant Engineer.

Col. WALTER GWYNN,
Chief Engineer James River and Kanawha Canal.

Approved and submitted in lieu of any report of my own, as is usual upon surveys made under my direction.

WALTER GWYNN,
Chief Engineer James River and Kanawha Canal.

Table of rain-gauges.

	At Anthony's Creek.								At White Sulphur Springs.							
	1847–'48.		1848–'49.		1849–'50.		1850–'51.		1847–'48.		1848–'49.		1849–'50.		1850–'51.	
	Meters.	Parts.	Meters.	Parts.	Meters.	Parts.	Meters.	Parts.	Meters.	Parts.	Meters.	Parts.	Meters.	Parts.	Meters.	Parts.
September . . .	22	6	24	5	11	3	6	2	21	5	20	4	16	0	6	2
October	33	0	11	3	34	3	21	5	30	7	20	7	30	3	21	5
November	44	4	35	4	11	0	31	6	42	7	35	3	10	0	31	6
December	32	1	42	1	56	6	46	3	37	8	43	5	56	0	44	2
January	23	0	25	5	38	7	5	0	22	7	26	5	36	3	3	5
February	33	3	23	7	31	9	32	2	32	2	22	5	26	8	32	9
March	44	6	42	0	23	0	24	4	48	2	40	8	23	3	24	4
April	17	7	19	3	35	8	28	4	21	6	20	8	45	6	28	2
May	51	9	32	3	53	1	40	5	39	9	33	1	53	1	27	2
June...........	11	9	20	5	40	1	17	7	16	0	39	0	25	6	25	5
July	41	7	58	6	12	0	49	6	57	2	45	8	30	6	86	0
August	38	7	35	0	42	0	18	8	36	2	13	2	46	1	18	8
Total	394	9	371	1	388	8	322	2	406	7	361	6	399	7	350	0
Inch	39.49		37.11		38.88		32.22		40.67		36.16		39.97		35.00	

SUPPLEMENTAL REPORT ON THE SURVEY OF THE SUMMIT-LEVEL, BY MR. E. LORRAINE, ASSISTANT ENGINEER JAMES RIVER AND KANAWHA CANAL.

PATTONSBURGH, *October* 5, 1852.

SIR: I had the honor of submitting to you in January last a report upon the survey of the summit-level, and upon the supply of water which might be obtained for the navigation of the canal. The calculations for the water-supply were based upon accurate surveys of the basins of the various creeks from which it was supposed to feed, and upon the observations of the downfall of rain for the four preceding years.

To the engineer or to the man of science this method is perfectly satisfactory, because he knows it is customary, and that where it has been tested the practical results have always proved that the theory was correct. But to the person unaccustomed to scientific investigations the whole process appears to be chimerical, at least, if not eminently ridiculous. Such persons regard the scheme of carrying the canal over the Alleghany Mountains more as one of the reveries of a lunatic than as the sober thought of a sound practical mind. And the notion of its impracticability is based mostly upon the idea that it will be impossible to obtain water sufficient to supply the summit-level. The enemies of the canal have taken advantage of the ignorance of the people, and endeavored to plunge them into still greater darkness, either by the misrepresentation of facts or by the suppression of the truth. The country about the summit-level has been represented as a region of parched and arid rocks, upon which the rain never falls, or if it does, only to be swallowed up by innumerable chasms. The creeks and streams are said to be all *dry*, and the only hope of supplying the canal is from a few holes to be dug in the mountains, which are to be filled from the mists and dews of heaven.

The object of the survey which you caused to be made last year was to remove all doubt as to the practicability of prosecuting the water-line to the Ohio. A report was made upon that survey, which I believe satisfied yourself and every candid friend of truth that the water line was practicable, and that the summit-level could be amply supplied at a very moderate cost. The estimates, however, of the supply of water were based upon the downfall of rain. But as it has seemed heretofore a great mys-

tery to the people of Virginia how it was possible for a canal to be supplied by rain, forgetting that the Mississippi River receives its annual supply from the same contemptible source, it was desirable that the subject should be investigated in another way, which should be more practicable and tangible to the eyes of even those who do not wish to see; and as there seems to be such an objection to the canal being supplied in the same way as our rivers, lakes, and seas, it was hoped that if it could be clearly proved that Anthony's Creek itself, apart from all connection with the clouds and rain, actually discharged enough water to supply the canal, that then the mystery would be solved and the most incredulous would become convinced. For this purpose you instituted daily gauges of Anthony's Creek, to be continued for one year. Accurate sections of the creek were taken in three different places, and it was so arranged that it was only necessary that the width and velocity of the creek should be measured daily and reported by a careful and intelligent person. Such a person we found in Col. Andrew Humphreys, who deserves great praise for the punctuality and faithfulness with which he has discharged the important duties which were assigned to him. The gauges have been regularly taken, the reports have been sent in, and are now before me with the calculations deduced from them, which I now beg leave to submit to you.

Table of the quantity of water discharged by Anthony's Creek in one year.

Months.	Cubic yards of water discharged per annum.
January	11,649,673
February	40,028,402
March	38,455,895
April	45,333,023
May	13,262,939
June	19,308,086
July	4,596,482
August	7,071,280
September	1,194,789
October	780,491
November	6,963,657
December	21,393,063
Total	210,526,955

The above is the quantity of water which actually flowed down Anthony's Creek in one year.

In making my calculations of the supply of water from the downfall of rain, I assume an estimate of 40 per cent. as the quantity of rain that would be drained off into the creeks and that could be collected in reservoirs. I assume this quantity because it is the same as was reported by Mr. Ellet as the drainage of the valley of the Ohio, and by Mr. Jervis as the drainage into the reservoir of the Chenango Canal. I, however, stated that the drainage in other localities has been found to be as much as 60 per cent. of the rain that fell, and ventured the assertion, from my knowledge of the peculiar formation of the basin of Anthony's Creek, that its drainage would amount to even more than 60 per cent. In that conclusion I am now sustained by the facts which have since been elicited by the gauges of the creek. The rain-gauges for the same year give 34.23 inches as the downfall of the rain, equal to about 300,000,000 cubic yards of rain, of which about 210,500,000 cubic yards, or 70 per cent., was drained off and discharged by the creek. I observe, however, upon a comparison of the rain-register and the gauges of the creek, that the latter was sometimes very much swollen from rains not indicated by the rain-register, and which must, therefore, have fallen near the head-waters of the creek. That being the case, it is safest to assume the downfall of rain at what it has averaged for the last five years, viz, 36.386 inches. It is also proper to deduct from the annual discharge of the creek a constant quantity equal to 365 times its least daily discharge, which is about 2,000,000 cubic yards per annum, which may be considered as supplied by springs. This quantity being deducted, leaves the drainage into the creek equal to 208,526,955 cubic yards. The downfall of 36.386 inches gives 318,738,394 cubic yards of rain. The drainage is therefore 65¼ per cent. of the downfall of rain. This is a mere matter of philosophical inquiry, in no way connected with the supply of the summit-level, as it is intended in the present investigation to ignore rain altogether until it becomes creek-water. It is only alluded to as establishing an interesting meteorological fact, based on carefully-conducted experiments on a very large scale.

To those persons who have heretofore been impressed with the idea that the streams about the summit level are nearly dry or lose themselves in immense chasms, it may

appear strange that so great a quantity of water should pass down Anthony's Creek. To those who live upon the creek it will be nothing new. They have seen it as I have, when swollen by rains, rushing through the "Narrows" with an impetuosity and volume almost incredible. I have myself seen it discharge in one day a sufficient quantity of water to fill the entire canal from Buchanan to Richmond, or 200 miles of canal 40 feet wide and 5 feet deep. I have also seen it wide enough, deep enough, and swift enough to carry seven of our largest freight-boats abreast at the rate of 5¼ miles an hour.

The quantity of rain which fell last year was only 34½ inches, which is considerably below the average. Neither was there any remarkable freshet in the creek beyond that in common to it every year. We may therefore assume the above quantity of 210½ millions cubic yards are the average yearly supply. The question then is, is it enough for the wants of the canal?

I have estimated the quantity of water necessary for the supply of the summit-level at 95,970,545 cubic yards per annum; this was supposing a boat passed the summit-level every six minutes in every day for 365 days, which is a very extravagant calculation; for if you allowed every boat to carry 50 tons it would make an annual tonnage of 4,380,000 tons.

	Cubic yards.
The quantity allowed for filtration and evaporation in the five reservoirs and feeders was	25,914,820
Which added to	95,970,545
Gives	121,885,365
as the total quantity to be supplied.	
Anthony's Creek yields us	210,526,955
We therefore have a surplus of	88,641,590

for contingencies.

In the above calculation I have allowed for filtration and evaporation in five reservoirs, which is also an extravagant amount, as we are supposing but one to be in use.

It is an undeniable fact, then, that Anthony's Creek alone affords a sufficient quantity of water to supply the summit-level. If that were the only stream upon which we had to depend there would be no obstacle to the passage of the canal over the mountains. But there are three other creeks, viz, Little Creek, Tuckahoe and Howard's Creeks, whose united volume amounts to about one-third of Anthony's Creek, which, if necessary, could be appropriated for the use of the canal.

Anthony's Creek being proved sufficient, the only question, then, is, can it be made available at a reasonable cost?

If a Virginia farmer has a small stream running through his plantation, and he wishes to erect a mill upon it, all that he does is to build a dam across the valley of the stream and put his mill up near it, nothing doubting that the dam will stop up the water and form a pond, from which the desired water-power can be obtained. He does not employ a geologist to tell him whether his pond will hold water or not. He goes ahead, with perfect confidence that the water can be dammed up and made available. The James River and Kanawha Company can go ahead with the same confidence and dam up Anthony's Creek. The operation is exactly the same, only upon a large scale, and with the additional security that the basin of the creek has been examined by an eminent geologist, who pronounces the rocks to be in the best possible position to retain the water. After the mound is made, the creek itself will fill the reservoir, and keep it full, besides supplying all the demands of the canal.

It will require a tunnel 2¼ miles long to conduct the water from the reservoir to the canal. This tunnel is through slate rock, and need only be 6 feet in diameter. The tunneling-machine lately put into operation at the Hoosac tunnel would walk through it in a very short time, or, even if it had to be excavated in the usual way, it could be done at a cost of about $300,000. The whole cost of supplying the summit-level wil not exceed $700,000.

All the fancied difficulties and impossibilities of supplying the summit-level, and consequently of carrying the canal across the mountains, vanish into thin air before this array of facts. It becomes, then, a mere question of policy or expense. In that light the subject ceases to come within the legitimate scope of this report. As you thought proper to assign me the duty of making the survey, I considered it within my province not only to submit the above facts, but the deductions to be drawn from them, and to dispel, as far as possible, the thick medium of prejudice and ignorance through which the subject has been heretofore viewed, not only by the enemies of the canal, but, I believe, by some of its best friends.

Very respectfully, your obedient servant,

E. LORRAINE,
Assistant Engineer J. R. & K. Canal.

COL. WALTER GWYNN,
Chief Engineer J. R. & K. Canal.

LETTER FROM THE SECRETARY OF WAR, TRANSMITTING A REPORT ON THE JAMES RIVER AND KANAWHA CANAL-ROUTE.

DOC. NO. 216. HO. OF REPS.; WAR DEPARTMENT; 20TH CONG., 1ST SESS.
March 24, 1828.—Read and laid upon the table.
Washington: Printed by Gales & Seaton, 1828.

WAR DEPARTMENT, *March* 24, 1828.

SIR: In compliance with a resolution of the House of Representatives, of the 2d of January last, I have the honor to transmit herewith a letter from the Chief Engineer, of this date, accompanied by a report on the James and Kanawha canal-route. To save time, it has been thought necessary to transmit the original report, which report, it is requested, may be returned to this Department, when it shall have answered the purposes of the House.

I have the honor to be, very respectfully, sir, your most obedient servant,

JAMES BARBOUR.

The Hon. ANDREW STEVENSON,
Speaker of the House of Representatives.

ENGINEER DEPARTMENT,
Washington City, March 24, 1828.

SIR: I have the honor to lay before you a letter from Capt. W. G. McNeill, of the topographical engineers, accompanied by his report on the route for a canal between the James and Kanawha Rivers, which report was called for by a resolution of the House of Representatives of the 2d January last.

I have the honor to be, very respectfully, your obedient servant.

ALEX. MACOMB.
Major-General, Chief Engineer.

Hon. JAMES BARBOUR,
Secretary of War.

GEORGETOWN, D. C., *March* 24, 1828.

SIR: I have the honor to transmit herewith a report on the James and Kanawha Canal, in illustration of which a map is now in the course of preparation.

All the maps and profiles relating to the experimental surveys are already completed, as well as those exhibiting the locations from the James to the Greenbrier River; the others, including the locations down the Greenbrier and New Rivers, are in progress of completion. There are in all nearly *thirty* large maps, including the plans and profiles, on a scale suitable to the exhibition of details; but they are too unwieldy to accompany the report, and are retained till they can be reduced into one general map. Most of the drawings in relation to the Roanoke and Kanawha Canal are nearly finished, but their size renders it necessary that they, also, be reduced into a more convenient shape.

I have the honor to be, sir, with great respect, your obedient servant,

WM. G. MCNEILL,
Captain United States Topographical Engineers.

Maj. Gen. MACOMB,
Chief Engineer, Washington City.

To Major-General MACOMB,
Chief Engineer:

SIR: In pursuance of instructions from the board of internal improvements, of July 29, 1826, predicated on the orders of the Chief Engineer, assigning to my brigade the execution of certain surveys, "to ascertain the practicability and means of connecting the waters of the Great Kanawha with those of the James or Roanoke River, by canals or railroads, or both, and also the connection of the Roanoke and James," I have now the honor to

REPORT

that the short interval which elapsed between the receipt of my instructions and termination of the first season was consumed in preliminary operations, which merely related to the first object to which my instructions referred, to wit, the practicability of a "connection of the Kanawha and James Rivers, by means of a canal;" that in

May, 1827, the surveys were resumed and continued till November; and that in that period the required location of a line of canal from Covington, on James River, to the foot of the Great Falls of Kanawha was effected, with that of all the works relating to a summit-level, such as feeders, reservoirs, &c., and the consequent location made, as enjoined, in the event of its practicability, of a canal from the forks of the Roanoke to the Great Falls of Kanawha River.

The subject under consideration naturally advances as our first inquiry, "the *practicability* of a connection of the Kanawha and James Rivers, by means of a canal," and, in contemplating such a connection, we are led, in the first place, to remark that the characters of the small tributaries which empty into the James or Greenbrier Rivers, (the country intermediate to those rivers being that under consideration,) like those of most mountain-streams, incontrovertibly prove their inadequacy to the permanent supply of a canal, and that, in consequence, the practicability of the project must depend on the adequacy of the Greenbrier River for that purpose, at some point whence its waters may be conducted to a summit-level of such elevation that the dividing-ridge may be passed without encountering an excessive length of tunnel.

To the solution of this question, then, various experimental lines were directed through the ravines, which, on the one side, bound the tributaries of Dunlap's Creek, and, on the other, through those which, heading opposite to them, define the course of either Second Creek, Howard's Creek, or Anthony's Creek, in their progress to the Greenbrier River, by which was ascertained the height of the dividing ridge in its greatest depressions, and a profile was carried up Greenbrier River to obtain such knowledge of its character as was indispensable to the judicious selection of a summit-level.

A comparison of the elevation of the dividing ridge, on any route examined, with that of the Greenbrier River, at any point within a reasonable distance, at once discloses the necessity of a tunnel; and that this, with every other fact connected with the subject, may be known, I proceed to detail the results developed in the course of our investigations.

As the basis of comparison in the description about to be given, all the heights and distances will be referred to the bench-mark, at the mouth of Dunlap's Creek, opposite to the town of Covington;* and to begin with that route which, from the near approach of the opposite streams, the gradual slope on either side of the dividing ridge, and the seemingly great depression of the Alleghany Mountains, might induce a belief of its paramount advantages, we shall describe—

FIRST—A ROUTE BY THE VALLEYS OF DUNLAP'S AND SECOND CREEKS.

Dunlap's Creek, or its main branch, (known as its south fork, on which are the famed Sweet Springs,) heads nearly on the summit of the ridge which divides it from Second Creek, and pursues its course at the base of Peter's Mountain, nearly parallel with the Alleghany Mountain, till within 6 miles of its mouth, when, having received the waters of Ogley's Creek, it continues in a direction in general nearly at right angles to its former course. Between its source and its confluence with Ogley's Creek several small runs contribute to its supply, such as Cove Creek, Fork Run, and Brush Creek; but they are noticed rather on account of their *directions*, which shall hereafter be alluded to, than because of any efficient aid to be derived from them toward the feeding of a canal.

Dunlap's Creek is, in general, bordered by flats varying in width from 250 yards to half a mile, although it may sometimes occur that the hills impinge so far upon the stream as to render it preferable to gain an opposite flat by an aqueduct (since bottom-land is always to be found on one side or the other, and the width of the stream never exceeds 35 yards) than to encounter the obstacles presented by steep side-lying ground in an attempt to avoid that expense. This remark, however, is applicable in a degree as well to all the other valleys through which experimental lines were run as to that of Dunlap's Creek.

For the first 22 miles the average rise in the stream may be assumed at 25 feet per mile, when for the next mile the regularity of its ascent is interrupted by falls and rapids comprising 135 feet; thence to the summit succeeds, first, an ascent for 8 miles of 73 feet per mile, and, in the remaining half a mile, a rise of 105 feet; making the distance of the summit from the base-mark 31½ miles, and its elevation 1,372 feet 7 inches.

A depression in the Alleghany Mountain west of that just alluded to induced another experimental line from Dunlap's to Second Creek; but of this suffice it to say it was found still higher, being 1,408 feet above the base-mark.

* The bench-mark at the mouth of Dunlap's Creek is 12 feet below a bench-mark established on the opposite side of the river, in 1819, by Messrs. Moore and Briggs, who reported the mouth of Dunlap's Creek to be 1,238 feet above tide-water. Our base-mark, therefore, which is about 2 feet above the water, may be assumed to be 1,240 feet above tide-water.

On descending Second Creek the slope from the summit to the Greenbrier River averages 337 feet per mile, with the exception of the first two and a half miles, in which the fall is 140 feet, or, in other words, the distance from the summit of the mountains to the mouth of Second Creek is 27 miles and the fall 967 feet, making the total distance from the mouth of Second Creek to that of Dunlap's Creek, by their respective valleys, fifty-eight and a half miles, and the Greenbrier River,* at the mouth of Second Creek, 406 feet above the base-mark.

Our present purpose, however, being merely, in the first place to show the relative altitudes of those depressions which suggested the different experimental lines across the mountain, and to compare them with the elevation of the Greenbrier River, that we may assume a summit-level which may command the waters of the Greenbrier without involving an impracticable length of tunnel, we shall confine ourselves to the few facts already stated, till, in succession, each route shall have as briefly been considered.

For obvious reasons, which will appear hereafter, (see page 767,) no other experimental lines were run from Dunlap's to Second Creek, nor was it deemed material, after a careful reconnaissance, that any tributary above Fork Run should be surveyed.

We shall then next describe that as the

SECOND ROUTE—BY DUNLAP'S CREEK, FORK RUN, AND HOWARD'S CREEK.

Howard's Creek, the first tributary of any note to the Greenbrier River above Second Creek, at the distance of seven miles from its mouth, is formed by the union of its three branches, which, from their relative directions, we shall designate as the South, the Middle, and the North Forks.

The South Fork rises near the heads of the upper branches of Dunlap's and Second Creeks, and pursues a course nearly parallel with Dunlap's Creek till it receives the waters of Tuckahoe Run, a small stream which empties into it near Comb's saw-mill.

The first depression remarkable in the dividing-ridge between Dunlap's Creek and the South Fork of Howard's Creek is found where the Alleghany is indented on the west by Tuckahoe, as it is on the east by Fork Run, an opposite tributary to Dunlap's Creek; and it is through this depression that the second route is directed. That part of the route between the mouth of Dunlap's Creek and Fork Run has already been described as ascending at the average rate of 25 feet per mile; thence to the summit of the mountain through the narrow valley of Fork Run (sufficiently wide, however, for a canal, the flats usually being from 100 to 200 feet wide) we ascend at a much more rapid rate, and, in the short distance of five miles and thirty-eight yards, rise 689 feet, making the height of the Alleghany, at the head of Fork Run, 1,092 feet, and its distance from the base-mark twenty-two and three-quarters miles.

The descent on the west, by the ravine of Tuckahoe Run, is very precipitous for 1 mile 593 yards, the fall, in that distance, being 331 feet; when, having arrived at the South Fork of Howard's Creek, the fall becomes quite gradual; the distance from the mouth of Tuckahoe to that of Howard's Creek being 10¾ miles, and the fall 315 feet.

The valley of Howard's Creek is, in general, wide, and under cultivation, and, with the exception of the short distance of one-eighth of a mile above Hunter's Mill, where the mountains on either side terminate in the stream, the construction of a canal would encounter no particular difficulty from the nature of the ground.

Fork Run, at the distance of 4 miles 750 yards from its mouth, branches in two directions, that which we have heretofore alluded to being the southern of the two; but as the Alleghany, where it divides the northern branch from the Middle Fork of Howard's Creek, presents another depression, through it was directed the

THIRD ROUTE—BY DUNLAP'S CREEK, FORK RUN, TO THE MIDDLE FORK OF HOWARD'S CREEK, AND THENCE BY THE VALLEY OF HOWARD'S CREEK TO THE GREENBRIER RIVER.

Of this route, although among the most promising, since, with the exception of a few miles, it occupies the same ground as the second route, but little need be said. The height of the dividing-ridge is greater than by the second, being 1,221 feet, and the access to the summit, on either side, more gradual. It does not, therefore, present as short a tunnel. Indeed, the only advantage which it possesses arises from its being nearer the Greenbrier River; and it will be shown hereafter how far that can place it in competition.

Brush Creek, the next tributary to Dunlap's Creek, has been enumerated among those whose direction claims some notice. But since the turnpike road, which pursues the valley of the South Fork of Ogley's Creek to its source in the ridge, crosses that ridge and enters the valley of Brush Creek several miles from the summit of the Alleghany,

* Viz, the bench-mark at the mouth of Second Creek.

instead of running a profile from the mouth of Brush Creek, it was thought sufficient to continue the profile from Ogley's Creek in the direction of the turnpike, and from the point at which it strikes Brush Creek to cross the Alleghany in the three depressions in which the several branches of Brush Creek head opposite the Middle and the North Fork of Howard's Creek; for it was apparent, if a tunnel should be requisite by either of the routes from Brush Creek, that its length, unless immoderate, would be included between the intersection of the turnpike with that stream and its corresponding elevation west of the mountain.

The first line from Brush Creek was directed through the gap occupied by the present turnpike road to the Middle Fork of Howard's Creek. It determined the height of that gap to be 1,288 feet. By the second line, the height of the depression through which the former road was located was found to be 1,252 feet; and, by the third line from Brush Creek, the elevation of the Alleghany, in a depression between it and the North Fork of Howard's Creek, was found to be 1,534 feet. It will be seen, on the assumption of a summit-level, that by no route from Brush Creek could the passage of the Alleghany be effected by as short a tunnel as will be found on other routes.

Ogley's Creek, the last tributary to Dunlap's Creek of any importance, alone remains to be spoken of. We have already incidentally mentioned, in describing the routes by Brush Creek, that its southern fork heads in a ridge between it and Brush Creek; but although the height of that ridge (it being 1,143 feet above the base-mark and 200 feet above its western base) would, of course, necessitate a longer tunnel from the South Fork of Ogley's Creek than from Brush Creek, and would, in consequence, oppose itself successfully to the location of a canal, yet, since the shortest route from the James to the Greenbrier River would be in the direction of the present turnpike road, in reference to the selection of the best route for a railroad, (an ulterior object contemplated by my instructions,) the valley of the South Fork of Ogley's Creek merits more consideration than if a canal alone were the subject of our investigations.

The valley of Ogley's Creek is not, either in quality of its soil or the nature of the rocks in its vicinity, particularly distinguished by any peculiar characteristics; for 3 miles from its mouth it affords a considerable quantity of rich productive land on the northern side, to which the flats are almost exclusively confined; and beyond that, as we approach the mountain by its South Fork, we find the valley contracted to a width of but from 50 to 100 yards.

The Middle Fork of Ogley's Creek, however, is the main branch, and it presents a wider valley throughout its course than that of the South Fork, with which it unites 9 miles from the base-mark, and 230 feet above it. Its direction corresponds nearly with that of the North Fork of Howard's Creek, and is such as to bring it nearer to Anthony's Creek than any other of the eastern tributaries; which fact rendered its examination the more important because of the advantages which would result from the proximity of a summit-level on Anthony's Creek to the source whence the supply of water is to be derived.

A profile was, therefore, continued throughout the whole length of the Middle Fork of Ogley's Creek, and thence down Anthony's Creek, with the intent to learn, as well if any depression existed between Ogley's and the North Fork of Howard's Creek, as the difficulties opposed to the route of a canal in the valley of Anthony's Creek. Of the one or two experiments made from the Middle Fork of Ogley's Creek to the North Fork of Howard's Creek, it is sufficient to state that although carried no great distance from the former, they conclusively proved that the height and width of the mountain between those streams rendered their connection impracticable.

The elevation of the Alleghany, where it divides the Middle Fork of Ogley's from the nearest head branch of Anthony's Creek, is 1,772 feet, and the distance to that point from the base-mark 20 miles and 1,100 yards; the descent thence to the base-mark at the mouth of Anthony's Creek (5 feet above the stream) was found to be 1,212 feet, and the distance 18¾ miles; hence the Greenbrier River at the mouth of Anthony's Creek is 555 feet above the base mark.

The profile from Ogley's Creek to the mouth of Anthony's Creek descended for 1¼ miles a mere ravine, which bounds the small tributary known as Laurel Run; but thence to within 6 miles of the mouth of Anthony's Creek, during which, from the accession from tributaries, its supply has become considerable, we in general find the stream bordered by fertile bottoms, under cultivation, from one-quarter to a half mile in width. Nor is it until it breaks through the Greenbrier Mountain (when the flats disappear) that either its descent is so rapid or its valley so contracted as to qualify it advantageously for the purposes of a reservoir.

It is only necessary now to add that a profile was carried up the North Fork of Ogley's Creek, till having risen 841 feet above the base-mark, we were satisfied of the inutility of proceeding farther, (since its source was known to be as elevated and more distant from Anthony's Creek than that of Middle Fork,) and it will be apparent, from an inspection of the map that no depression can exist in the ridge dividing the waters of Dunlap's Creek from those which flow into the Greenbrier River, which has not been sufficiently examined to enable us to determine the best route for the passage of the Alleghany—abstracting such considerations as relate to the supply of water.

These considerations now suggest as the subject of our next inquiry the character of the Greenbrier River, whose relative position to the different routes, or comparative supply at different elevations, is to be so influential in determining the proper elevation to the summit level.

The survey and level of Greenbrier River were commenced at a base-mark at the mouth of Howard's Creek, (5,935 feet above the then surface of the water,) and continued for 39 miles up the river, in which distance the ascent was found to be 318 feet, or the point at which we stopped is 770 feet above the base-mark. Anthony's Creek and Spring Creek are the only tributaries of much consequence intermediate to Howard's Creek and the "Droop Mountain," near which latter point the survey of Greenbrier River was discontinued, and, therefore, it was with less surprise we observed that the supply of water did not diminish very materially in our progress up the river, or that, on the contrary, it seemed to vary but little when, in passing over ledges, its whole volume could be estimated. For, as an exception to the apparent uniformity of its supply, it is to be remarked that, at times, the stream almost disappears among the loose stones and fissures of its bed, and that, in one case where a vein of limestone traverses its valley, all the water is passed through a subterraneous channel for the distance of a mile nearly. This, however, occurs but once, (in the twenty-third mile from Howard's Creek,) and then only in very low stages of the water.

Greenbrier River pursues a very sinuous course through a valley unusually contracted, when viewed with reference to the size of the stream, and, with some partial exceptions only, we find it, throughout the extent at present under consideration, bordered by high and rugged hills which descend steeply to the water's edge. There are, it is true, narrow strips of alluvial on one or the other side, but they are never continuous for any considerable distance, nor of such value as to merit consideration when their submersion shall be the consequence of such dams as might be desired for the formation of reservoirs.

The country west of Greenbrier River, although hilly, affords rich and arable lands; east of the river it is mountainous, and in general but illy-adapted to agricultural purposes. But, for a more minute description of the quality of the soil, vegetable and mineral productions, &c., and of the character of the country above Droop Mountain, resort may be had to the report of Lieutenant Dillahunty, which is appended to this report.

A reference to the profile of the river will show that the general and average rise of 7.6 feet per mile for 31 miles above Howard's Creek is but seldom interrupted; and that beyond that, or as we approach Droop Mountain, the average rise of the Greenbrier is about 10 feet per mile. The heights to which freshets rise above the ordinary bed of the stream vary, of course, with the slope and *width* of the valley. Traces of such as are known to be of frequent occurrence, at almost all seasons of the year, were perceived 6 and 8 feet above low-water mark, and indications were remarked of freshets having sometimes attained the height of 16 feet in the broadest parts of the river. The influence of but comparatively slight rains is very perceptible in the floods which succeed; and from their frequency and the magnitude of the volume which passes at such times, we have ample assurance that the most extensive reservoirs (for the formation of which the valley of Greenbrier is so admirably adapted) could be replenished as often as might be necessary.

To revert, however, to the relative elevation of the Greenbrier River, and of the Alleghany Mountains, in the different depressions heretofore recited, we readily perceive that the supply from Greenbrier, on which, as was premised, the practicability of the project rests, cannot be commanded within a reasonable distance without resorting to a tunnel; for the greatest depression in the Alleghany Mountains being 1,092.75 feet above the base-mark, while the elevation of Greenbrier River 39 miles above Howard's Creek is but 770.7 feet, at an average rise of 10 feet in the Greenbrier, beyond the point to which it was leveled, an elevation corresponding to that of the most depressed point of the Alleghany would not be attained in less than 71 miles from the mouth of Howard's Greek, and supposing *the spur which projects from the Alleghany, between the waters of Howard's and Anthony's creeks*, (p. 763,) sometimes called the "Greenbrier Mountain," (see map of experimental surveys,) to be passed without winding around its extremity near the mouth of Howard's Creek, the length of a feeder from the summit-level could not be much, if any, less than would be the distance from the mouth of Howard's Creek to the assumed elevation of the summit-level on the Greenbrier.

Besides, the ruggedness and steepness of the hills bordering the Greenbrier may be said to be almost in proportion to the elevation above the stream at which we encountered them; and on that account it would be desirable to run the feeder as low as possible, adding to these considerations the fears which might reasonably be entertained of the inadequacy of the Greenbrier to supply the losses of so long a feeder as would be required to pass the Alleghany without a tunnel, and the necessity of a tunnel would seem to be obvious.

This conclusion leads us to compare the lengths of tunnels at different elevations;

which, limiting the depth of cutting at which the tunnels are supposed to commence and terminate at 35 feet, are now exhibited in the following table:

TABLE.

Number of route.	Designation of route.	Elevation of the summit-level above the base mark.	Length of cut east of the Alleghany Mountains.		Length of cut west of the Alleghany Mountains.		Length of tunnel.	
		Feet	*Miles*	*Yards.*	*Miles.*	*Yards.*	*Miles.*	*Yards.*
1	From Dunlap's Creek to Second Creek	750	1	283	0	1,173	10	867
2	From Dunlap's Creek by Fork Run to south fork of Howard's Creek	750	0	400	0	547	2	210
3	From Dunlap's Creek by Fork Run to middle fork of Howard's Creek..............	750	0	400	0	1,000	3	800
4	From Dunlap's Creek by middle fork of Ogley's Creek to Anthony's Creek.........	750	0	727	2	943	4	883
5	From Dunlap's Creek by Ogley's to the north fork of Howard's Creek..................	750	0	383	0	1,285	5	1,523
6	From Dunlap's Creek by Ogley's Creek to the middle fork of Howard's Creek.......	750	0	383	0	1,000	6	783
1	....	700	1	283	0	1,217	11	....
2	....	700	0	430	0	1,017	3	333
3	....	700	0	430	0	901	4	317
4	....	700	0	717	3	500	5	1,716
5	....	700	0	300	0	860	6	1,187
6	....	700	0	300	0	901	6	1,500
1	....	650	0	440	0	1,550	11	933
2	....	650	0	350	1	73	4	....
3	....	650	0	350	0	1,013	5	150
4	....	650	0	684	1	793	9	773
5	....	650	0	30	0	1,320	7	760
6	....	650	0	30	0	1,013	7	547
1	....	600	0	293	0	1,650	11	1,277
2	....	600	0	407	1	964	5	600
3	....	600	0	407	1	190	5	1,217
4	....	600	0	660	1	427	10	1,067
5	....	600	0	283	1	156	8	720
6	....	600	0	283	1	190	8	383

By reference to the foregoing table, it is at once perceived that within the assumed elevations of a summit-level a shorter tunnel would be requisite to pass the Alleghany Mountain by the second or third routes than by either of the others; and it will also be seen that the length of tunnel increases very rapidly on either of those routes as we descend below 700 feet, while at any greater elevation the diminished length of tunnel does not constitute a sufficient advantage to compensate for the increased lockage, the greater length of feeder, or to induce us to forego the advantages of a reservoir on the Greenbrier in its passage through the Droop Mountain, when the fall of the river is known to be greatest, and its valley so contracted that the least area in proportion to the contents of the reservoir would be exposed to the influence of evaporation.

We therefore assumed a summit-level at the elevation of 700 feet above the base-mark, and from its western end on the second route a line of feeder was traced at an inclination of 6 inches per mile to its intersection with the Greenbrier River.

This line from the relative positions of the routes of course passed them all, (except No. 1, which was abandoned because of its excessive length of tunnel,*) and enables us to determine very nearly the lenth of feeder for any route.

Deferring at this time the more detailed account of the difficulties opposed to a feeder in its progress from the Greenbrier River to the summit-level of the second route—which as yet is conspicuous for its advantages over the other routes—it may

* To recur to the reasons why but one experiment was made from Dunlap's to Second Creek. The great length of tunnel by the first route could not be diminished by any route to Second Creek, for the mouth of Cove Creek (the next tributary to Dunlap's Creek above Fork Run) is 600 feet above the base-mark, and the rise in Cove Creek being greater than in Dunlap's Creek we should, by a route through Cove Creek, have to commence tunneling at even a greater distance from Second Creek than by the first route. Indeed, a route from Dunlap's to Second Creek would be impracticable at any rate, in consequence of its distance from Greenbrier River and of the character of the intermediate country. (p. 764.)

suffice our present purpose to state that the spur which was spoken of (page 766) as projecting from the Alleghany to the mouth of Howard's Creek, or which lies between Howard's Creek and the Greenbrier River, constitutes a great objection to every route but the fourth.

So circuitous a route for the feeder as that around the extremity of the spur might, and probably would, involve such losses in its course as to be fatal to the practicability of the project, while the alternative of passing the spur in the direction indicated by the near approach of two opposite tributaries to the north fork of Howard's Creek on the one side, and to Anthony's Creek on the other, however it may diminish the chance of an inadequate supply of water, or may assure us of a probable superabundance, is fraught with difficulty.

The greatest depression in the ridge intermediate to Howard's and Anthony's Creeks is at the sources of the two tributaries just alluded to, through which it had been hoped the feeder might reach the valley of Anthony's Creek by an open cut, or a tunnel of moderate length. But it was found to be 1,096 feet above the base-mark, and the slope on either side is so gradual, that limiting the cuts to 35 feet depth, a tunnel of 5 miles and 1,620 yards will be required. (p. 772.)

Were the summit-level 50 feet or even 100 feet higher than has been assumed, still the length of tunnel, to pass this ridge, would be, in the one case, 4 miles and 290 yards, and in the other, 3 miles and 533 yards. But the considerations which heretofore induced us to limit the elevation of the summit level to 700 feet cannot safely be waived; and therefore, in selecting the location for a feeder, the disadvantages of a tunnel of 4 miles and 1,620 yards, by one route, are to be weighed with the uncertainties attending the very greatly-increased length by the other.

In comparing the different routes for a canal, however, and the practicability of each, we shall confine our view to the shorter route for the feeder, and on that supposition the following table comprises their principal characteristics:

TABLE.

No. of route.	Cut east of the Alleghany.		Cut west of the Alleghany.		Length of tunnel.		Length of the summit-level.		Distance from base-mark to summit-level.		Distance thence to mouth of Howard's Creek.		Total distance from base-mark to mouth of Howard's Creek.		Height of Alleghany.	Feeder to the summit-level.	
	M.	Yds.	M.	Yds.	M.	Yds.	M.	Yds.	M.	Yds.	M.	Yds.	M.	Yds.	Feet.	M.	Yds.
2.......	0	430	0	1,017	3	333	4	20	20	913	8	1,713	33	866	1,092	38	623
3.......	0	430	0	901	4	317	4	648	20	913	8	880	33	1,631	1,221	35	1,153
....	0	717	3	500	5	1,716	9	173	16	220	19	1,000	45	633	1,772	26	403
5.......	0	360	0	860	6	1,187	7	587	11	1,540	9	130	28	597	1,534	33	1,723
6.......	0	300	0	901	6	1,500	7	941	11	1,540	8	880	27	1,601	1,288	35	1,153

NOTE.—The last column develops the length of the feeder as actually traced, but it became apparent on plotting the work that judicious deviations from the first trace would reduce the longest feeder to about 33¾ miles, and the others in proportion.

The shorter tunnel required by the second route, to pass the Alleghany Mountain, is decisive of its preference over any route but the fourth, which, being nearer the Greenbrier River, and alone exempt from the difficulties which attend a feeder to any summit-level beyond Anthony's Creek, we shall compare more closely with the second route.

The fourth route is 11¾ miles, the longer of the two; and the length of its tunnel through the Alleghany exceeds that of the second route by 2 miles 1,483 yards; while, by the fourth route, we avoid 12 miles of feeder, which includes a tunnel of 4 miles and 1,620 yards.

Now, the cost of constructing 12 miles of feeder, even with a tunnel of 4 miles and 1,620 yards, certainly, I think, would be less than the cost of 2 miles 1,483 yards of a tunnel of such dimensions as would be adapted to the navigation of canal-boats; and, to say nothing of the cost of 11¾ miles of canal, on the score of comparative expense, the second route would be preferable to the fourth. If, therefore, it shall appear that, notwithstanding its greater length of feeder, an adequate supply may be depended on, since the accomplishment of the same objects would result from the adoption of either route, the difference of expense in favor of the second route will be considered conclusive of its preference.

Without entering into a recapitulation of all the calculations to be found in Lieutenant Dillahunty's report, relative to the supply of water, we shall, as concisely as

may be, state the results which have, in our view, established the practicability of the project under consideration.

From a careful and repeated ganging, at intervals during two successive years, of the streams on which we rely, we find that their minimum supply was as follows, viz:

	Cubic feet per second.
Greenbrier River	43.3
Anthony's Creek	11.6
Dunlap's Creek	9.3
Howard's Creek	6.83

Besides which, a reservoir may be formed on the Greenbrier River, above the commencement of the feeder, to the summit-level, by a dam 50 feet high, which shall contain 13,060,584.9 cubic yards.

To compute the sufficiency of this supply, let the same suppositions apply to this route as were adopted by the United States board of internal improvements with regard to the proposed Ohio and Chesapeake Canal.

They have assumed an interruption of the navigation during the winter season, which, from the elevation of the summit-level, 1.903 feet above the ocean, they suppose to include the four months of December, January, February, and March. The summit-level of the proposed James and Kanawha Canal, it is true, is further south, but it is equally elevated, (1,940 feet above the ocean,) and I have not perceived any essential difference in the climate.

During such a suspension of the navigation, if we only adopt 67.6 cubic feet per second as the mean discharge of the Greenbrier, (whereas we believe that to be much less than the mean discharge during the summer months,) it will be found that the reservoir would be filled twice, or once in about two months; and if we add to this view a computation of the supply we may reasonably expect from rains, the replenishing of the reservoir will not only seem certain, but the superabundance from that source alone will appear more than ample to repair all losses attributable to the reservoir and feeder, from the influence of evaporation, absorption, &c.

From an inspection of the map of Virginia, and our own knowledge of the extent of country drained by that part of Greenbrier River above the reservoir, we know that the sum of the lengths of the streams exceeds by far 110 miles; and that an average of the widths of their valleys is more than half a mile. But if we assume that an area of but 55 square miles is drained by the upper part of Greenbrier and its tributaries, and calculate on no greater annual fall of rain in the elevated region in which it is situated than was observed to be the least quantity which fell in the vicinity of Baltimore in any one year during a period of eight years, we find that an area of but 55 square miles would receive during—

	Cubic yards.
The fall and winter	78,880,384
The spring and summer	59,117,696
The whole year	137,998,080

From which, to continue the reasoning of the board, it is seen—1st, that two-thirds of the first quantity, or 52,586,929 cubic yards, is more than four times as much as will be necessary to fill the reservoir in four months; and 2d, that 59,117,696 cubic yards, or the second quantity, is equivalent to upward of 100 cubic feet (102.63) per second, during six months, and might be deemed the mean discharge during the spring and summer months, instead of 67.6 cubic feet, which we have assumed for the mean supply of the winter months. That the truth of this last deduction may be less doubtful, it is to be remarked that if we have apparently lost sight of the filtrations and evaporations of rain-water, 55 square miles is by no means equal to the whole extent of country drained above the reservoir; that the usual quantity of rain is much greater than has been assumed; and that our own observations would lead us to believe the mean supply of Greenbrier River during the summer months to be more than 100 cubic feet per second.

However, to forego further speculation, and to return to the supply of water on which, by the most unfavorable supposition, we may rely—omitting at this time the supply from Dunlap's Creek and Howard's Creek, which is taken in below the summit-level—we have a reservoir with an area of 2,508,333 square yards, whose prism of available water is 13,060,584 cubic yards; 43.3 cubic feet per second from Greenbrier River, and 11.6 cubic feet per second from Anthony's Creek; or, a total supply from Greenbrier and Anthony's Creek of 54.9 cubic feet per second—say 55 cubic feet.

This quantity is to meet the losses of a feeder 33¼ miles long, to supply the lockage of the canal, and the losses by filtration and evaporation of the summit-level, and the portions of canal on either side of it, which, together, include about 11¾ miles—besides making up such deficiency as may arise from the inadequacy of Dunlap's Creek, to supply about 17¾ miles of canal; and of the Howard's Creek, to meet the losses of but 4 miles of canal.

We impute no loss to the reservoir from filtration and evaporation, both because we are assured that the mean discharge from Greenbrier River, beyond what we have assumed to be the *minimum*, renders such an allowance unnecessary, and because the shape of the valley will admit the raising of the dam to any height to add to the reservoir a sufficient quantity to overbalance it.

We may calculate, then, on a monthly supply of 1,632,573.1 cubic yards from the reservoir, 5,168,888.08 cubic yards from Greenbrier River and Anthony's Creek, or 6,801,461.18 cubic yards for the total monthly supply. From this quantity, however, we must deduct, to obtain that available at the summit-level, the losses of the feeder in its course from Greenbrier River. With an area for its transverse section of 10 square yards, and a length of 33¾* miles, the feeder will contain 592,535 cubic yards, and we will make the extravagant supposition that it may lose the whole of its prism every 15 days, or 1,185,070 cubic yards per month. Deducting this quantity from the total monthly supply, there will remain 5,616,391.18 cubic yards, which is thus compared with the remaining requisitions dependent on it.

Waiving a particular recital of the arrangement of the trade, we will suppose it limited to 100 boats per day; that the boats pass the locks alternately, and that, consequently, no boat would of necessity expend more than one lock-full of water in its passage to the summit-level. But, as a prudent provision for contingencies, let it be assumed that each boat will require a lock-full and a half, or, the locks being of the same dimensions as were proposed for the Ohio and Chesapeake Canal, 623 cubic yards. The monthly allowance for lockage, then, if 3,000 boats should pass the summit-level, will be 1,869,000 cubic yards, which, taken from 5,616,391.18 cubic yards, (the available supply after deducting the losses of the feeder,) leaves 3,747,391.18 cubic yards. If this residue were all that we could command to supply the canal in its whole course from the mouth of Dunlap's Creek to the mouth of Howard's Creek, a distance of about :3½ miles, whereas not quite half that distance is dependent on it, it would abundantly meet all the losses of the canal from absorption, filtration, and evaporation.

But let us add to this residue but 5 cubic feet per second for the supply from Dunlap's Creek—but little more than half the minimum supply we have ever known it to yield—and 6 cubic feet per second from Howard's Creek, and we shall realize an accession to our monthly supply of 1,056,000 cubic yards, or we shall have 143,384.8 cubic yards per month per mile to secure the canal from its losses by evaporation, absorption, and filtration, an allowance equivalent to nearly 90 cubic feet (89.6) per mile per minute.†

The relative situations of the Cheat and Greenbrier Rivers, with the opportunity of forming a succession of reservoirs in the valley of the latter, suggest additional security against any probable failure in the supply of water; but it is needless to amplify a discussion already so far extended that the most cautious may not cavil at the conclusion that a canal from the James to the Kanawha River, by the valleys of Dunlap's and Howard's Creeks, is demonstrably practicable.

To the determination of this question, I have before remarked, all the preliminary operations of the first season were exclusively directed; and, so far, we have been confined entirely to the results afforded by the experimental survey. But, pursuant to my instructions, that, "for the practical works, the surveys must be performed in such a manner as to afford the route itself of the work, with all the circumstances of the ground which have a bearing upon excavation, embankment, crossings by aqueducts and culverts, dams, &c.," when, in May, 1827, the surveys were resumed, the precise location of a line of canal from the respective heads of boat-navigation on the James and Kanawha Rivers was the next object which occupied my brigade.

The location of that portion of canal between Covington and the mouth of Howard's Creek with that of all the works connected with the summit-level, such as feeders, reservoirs, &c., was constituted one object, and its accomplishment assigned to Lieutenants Cook and Fessenden. The continuation of the canal through the valleys of Greenbrier and Great Kanawha Rivers, from the mouth of Howard's Creek to the foot of the Great Falls, with all the considerations incident to the project, another object, the accomplishment of which was intrusted to Lieutenants Hazzard and Thompson.

The reports of Lieutenants Cook and Hazzard, which are hereto appended, with the different maps and profiles relating to the route, will fully exhibit the details which I

* See table, page 768.

† The United States Board of Internal Improvements, in their report of October 23, 1826, on the Ohio and Chesapeake Canal, (page 54,) admits the sufficiency of 120.000 cubic yards per mile per month as an allowance for absorption, evaporation, and filtration. And Dr. William Howard, United States civil engineer, in his "report on the survey of a canal from the Potomac to Baltimore," remarks that "1¼ cubic feet per second per mile appears a far more ample allowance than will be needed for the lockage, evaporation, and filtration of a canal placed in favorable circumstances for retaining water."

may omit to mention, such as the length of each level, the lift of each lock, the transverse as well as longitudinal slope of the ground, including the works, the nature of the soil, rocks, &c., the height of the freshets. It will remain to me, however, to present a connected and more general view of the whole route.

To facilitate a perspicuous arrangement of the subject, let the first section extend from the James to the Greenbrier River; the second section include that portion of the canal along the Greenbrier; and the third section that portion between the mouth of Greenbrier and its termination at the foot of the Great Falls of Kanawha.

First section.—The minuter surveys incident to the locations included in this section, while they test the accuracy of the experimental surveys, develop results somewhat different. The elevation of the summit-level, for instance, was established at 694 feet instead of 700 feet as heretofore assumed, and the depth of cutting at either end of the tunnel through the Alleghany was extended to 50 feet, instead of 35 feet, to which, in comparing the lengths of tunnels by the different routes, we had limited it. The reasons for changing the elevation of the summit-level are not, perhaps, important, but the depth of cutting was extended to 50 feet because it was found that the tunnel would be materially shortened; illustrative of which fact I would add, that on the western side alone, the length of the tunnel is diminished 533 yards by extending the cut to the depth of 50 feet.

Dividing this section into three parts, the first subdivision will comprise the summit-level and all the works belonging to it. The length of the summit-level is 4 miles 789 yards, which distance includes a short basin of 98 yards in the valley of Fork Run; a deep cut at the eastern end of the tunnel of 458 yards; a tunnel through the Alleghany of 2 miles and 1,120 yards; a cut at the western end of the tunnel of 1 mile 177 yards, and a basin from the termination of the latter cut, which extends 696 yards.

The profile of the ridge immediately over the tunnel indicates frequent great depressions, where it crosses the ravines of the head branches of Fork Run and Tuckahoe, although between those depressions the ridge sometimes attains a very great height above the summit-level. But the necessity, and to what extent, of sinking shafts in the construction of the tunnel, where those depressions do not exist, will be better seen by designating their position in the following tabular form:

Number of depressions.	Distance from the end of the deep cut at the eastern end of the tunnel.		Height of depression above the summit-level.	Greatest height of intermediate ground.	Distance from each depression to the one preceding.
	Miles.	Yards.	Feet.	Feet.	Yards.
1	0	500	160	245	500
2	0	740	166	203	240
3	0	953	126	249	213
4	0	1,183	180	230	230
5	0	1,516	300	374	333
6	1	353	276	578	597
7	1	773	458	560	420
8	1	1,017	515	605	244
9	1	1,677	205	706	660
10	2	500	130	368	583
11	2	1,120	50	324	620
					End of tunnel.

In relation to the probable formation of the ridge through which the tunnel would pass, of course we cannot speak with any certainty; but appearances at and near the surface in the vicinity would incline us to expect the interposition of compact sandstone the greater part of the distance. The cutting at either end of the tunnel, it is thought, will prove as favorable for its depth as could reasonably be expected anywhere; it will probably consist principally of an argillaceous slate and sandstone of slaty structure, intermixed with a soil (nearer the surface) of sand and clay.

Feeder from the Greenbrier River to the summit-level.—The location of this work does not vary materially from that pursued by the experimental surveys. Its length has been diminished to 31 miles 130 yards, but it still involves a tunnel of 5 miles and 200 yards. The same formation will doubtless be encountered by this tunnel as by that through the Alleghany Mountain; and the cutting, at either end of the tunnel, will be similar to what is expected in the deep cuts of the summit-level.

The height of the ridge above the surface of the water in the feeder, at different points from the beginning to the end of the tunnel, is shown in the following table:

Number of depressions.	Distance from the end of the deep cut at the beginning of the tunnel.		Height of depression above the surface of the water in the tunnel.	Greatest height of intermediate ground.	Distance from each depression to the one preceding.
	Miles.	*Yards.*	*Feet.*	*Feet.*	*Yards.*
1	....	1,260	100	262	1,380
2	1	690	153	199	1,190
3	1	1,006	204	253	316
4	1	1,374	211	351	368
5	2	409	298	547	795
6	2	799	373	424	390
7	2	1,066	419	550	267
8	2	1,426	356	604	360
9	2	1,622	482	529	196
10	3	52	513	599	190
11	3	362	772	804	310
12	3	675	718	799	313
13	3	888	733	747	213
14	4	15	703	929	887
15	4	155	712	777	140
16	4	435	852	898	280
17	4	735	897	954	300
18	4	1,235	585	Descending.	500
19	5	200	35		725

The tunnel begins and ends where the cutting is about 35 feet deep.

It will have been observed that the height of the ridge above the tunnel far exceeds the height of the depression spoken of, (page 768,) and the observation leads to the inquiry if it might not be better to give the tunnel the direction of those valleys which head in that depression, instead of a perfectly straight direction through the ridge. In that event the greatest height of the ridge above the tunnel need not exceed 300 feet, and the profile will show that on both sides the ground rapidly falls to within 150 feet above the tunnel.

We could conform to the direction of the opposite valleys, and continue the tunnel straight, or very nearly so, till it reached the valley at Anthony's Creek, when one turn would be necessary. Its length, under those circumstances, would be 5 miles and 950 yards, or it would be but 750 yards longer than if it were perfectly straight. I am, however, rather inclined to think it fortunate that such appalling difficulties as would obstruct the progress of a straight tunnel can so easily be diminished than to hesitate in recommending the longer tunnel because of its increased length; and I would therefore add, for the whole length of the feeder, the difference between the lengths of the two tunnels, to 31 miles 200 yards.

Lieutenant Cook's report will furnish every other fact connected with the feeder from Greenbrier River, or relative to the reservoir on that river. The feeder from Anthony's Creek he has omitted to mention intersects the main feeder in the 11th mile from the summit-level; it is one mile and 1,509 yards long, and passes down the right shore of Anthony's Creek without any difficulty. The dimensions of the dam at the head of this feeder are shown on the map.

SECOND SUBDIVISION.

This extends from the eastern end of the summit-level to the James River, opposite the town of Covington, and includes 19 miles and 73 yards of canal, and 692 feet of lockage, to the surface of a basin suitable to the reception of the canal-boats.

For the first 2 miles and 1,072 yards from the summit-level, or that included in the valley of Fork Run, we unavoidably fall 264 feet; preserving, however, with some exceptions, in which resort is had to contiguous locks, a succession of short levels, connected by locks of 8 feet lift.

The descent from the first to the second level, and from the seventh to the eighth level, was effected by two contiguous locks; while the third and fourth levels are united by five, and the tenth and eleventh levels by four, contiguous locks.

The actual descent of the valley in positions where it was essential to conform as much as possible to that descent to avoid rocky and precipitous slopes, which would else have been encountered, or, in other cases, expensive and deep embankments over broad and deep ravines—in fine, a regard to the various circumstances of the ground—sometimes recommended a combination of locks in preference to a succession of levels. Even with such a disposition as was made of the locks, the canal down the valley of Fork Run passes along a very steep slope, varying from 12° to 35°, till within about ¾ of a mile of Dunlap's Creek, when it occupies a flat.

For the remainder of this subdivision (16 miles and 761 yards) or that in the valley of Dunlap's Creek, the canal was located under much more favorable circumstances, the fall being much less in a given distance and the valley much wider. As I have remarked in another part of this report, bottom-lands always present themselves on one or the other side; and although these alternate with bluffs and occasional cliffs, which have more than once induced us to cross the stream, neither the lengths nor heights of the aqueducts would be such as to render them very expensive. It may be satisfactory, however, to observe that, whatever difficulty may have presented itself on one side, the creek has never been crossed till, from an actual experiment on both sides, it seemed proper to do so; and the field-notes may therefore be referred to for the precise motives which determined the location adopted for the canal.

From the mouth of Fork Run to its termination opposite Covington the canal is divided into 50 levels, connected with each other, as heretofore, by locks of 8 feet lift, except in three instances, where the descent is made by two contiguous locks. The descent from the last level to the basin proposed at the end of the canal is effected by a lock of 12 feet lift.

The excavation along Dunlap's Creek will, in general, be of the easiest kind, through bottoms or along hill-sides of sand and clay, sometimes mixed with argillaceous slate. The bottoms are uniformly composed of a vegetable mold about a foot thick, resting on a bed of clay. Limestone is found in the valley of Dunlap's Creek, opposite the canal, near Crow's tavern, and in several other places; but it was not observed to intersect our line; in fact, we have little apprehension that the canal would experience more than the ordinary losses incident to similar works favorably situated for retaining water.

Provision was made for the introduction into the canal of the supply afforded by Dunlap's Creek; it is to be very easily effected by a short feeder of but 610 yards' length, from a dam barely high enough to divert the course of the stream. The situation of the dam is not far below the mouth of Fork Run, and the level into which the supply is introduced is 2 miles and 1,718 yards from the summit-level.

THIRD SUBDIVISION.

This comprises a succession of short levels, connected by single locks of the uniform lift of 8 feet, and extends from the western end of the summit-level through the valley of Howard's Creek to the left bank of Greenbrier River. It includes a distance of 8 miles and 155 yards and a descent of 216 feet.

It is unnecessary, however, to dwell upon this subdivision; it presents no difficulty deserving of particular comment, and all its features are sufficiently developed on the map. The supply from Howard's Creek, if at all needed, may, perhaps, with most facility, be brought into the sixteenth level, which begins just below a very rapid part of the creek. A feeder of but 333 yards' length, with a dam 20 yards long and 7 feet high, would be sufficient.

A review of the first section of the canal affords the following summary of some of its principal features

	Distance.		No. of locks.	Ascent.	Descent.
	Miles.	*Yards.*		*Feet.*	*Feet.*
James River to summit-level	19	73	86	692	....
Summit-level	4	789	....	....	....
Summit-level to Greenbrier River	8	155	27	....	216
Total	31	1,017	113	692	216

Feeders.	Length.	
	Miles.	*Yards.*
From Greenbrier River to summit-level	31	130
From Anthony's Creek to main feeder	1	1,509
From Dunlap's Creek to twenty-seventh level of canal	....	610
From Howard's Creek to sixteenth level of canal	....	333
Total length of feeders	33	882

I have omitted to advert to the diminished contents of the reservoir on Greenbrier River resulting from Lieutenant Cook's selection of the site for a dam, (see his report, page 787.) because no doubts as to the adequacy of the supply have arisen from that circumstance. For it will be perceived that, by increasing the height of the dam

to 60 feet, we can reserve 14,000,000 cubic yards, instead of 13,060,584, on which latter quantity our former reasoning was predicated, and which, it has been shown, would leave a superabundance beyond all the wants of the canal.

Second section.—The first section terminating but 33 feet above low-water mark, viz, the surface of canal, it is thought advisable to prolong that level across the river; for the height to which freshets sometimes rise might else endanger the security of the aqueduct.

The length of the aqueduct under those circumstances would be 167 yards, at the end of which we descend by two locks, of 8½ feet lift each, to what Lieutenant Hazzard terms his first level. An additional supply of water may with great ease be introduced into the canal on either side of the river, even at the elevation of the aqueduct. A feeder on the left shore of but 1,260 yards in length, from a dam 13 feet high and 108 yards long, would effect the object. But I think it to be preferred that the new supply be admitted just beyond the aqueduct, from which to a dam of even less elevation a shorter feeder along the right shore would answer equally well.

Arrived at the first level beyond the aqueduct, the location of this section was continued, under various circumstances, to its termination at the mouth of Greenbrier River. The cliffs which impinge upon the stream, and which at times the canal unavoidably encounters, may rather be considered exceptions to the otherwise generally favorable nature of the ground, than as characterizing this section as at all remarkable for the extent of the obstacles to its easy execution.

Its length is 49 miles and 151 yards, which distance is subdivided into 36 levels, (the aqueduct being included,) united by locks of the uniform lift of 8 feet, excepting the two locks of 8½ feet lift at the end of the aqueduct across the Greenbrier. The canal therefore descends 297 feet in its progress to New River.*

The only tributary streams of any consequence crossed by this section of canal are Mill Creek, Muddy Creek, and Hunger's Creek; the first requiring an aqueduct 100 feet long and 17½ feet high, and the two others aqueducts of but 50 feet length and 17½ feet height. It does not appear advisable to introduce either of them into the canal; for every facility exists for obtaining an abundant supply from the river, to which we must necessarily resort. Suitable sites for dams across Greenbrier very frequently occur, but their position and dimensions will readily be seen on reference to the maps.

On the left, or east side, as we descend below Howard's Creek, the number and magnitude of the tributary streams are also so limited, that we are led to ascribe the increased size of Greenbrier River, observable in its progress to New River, rather to the existence of numerous springs which rise within or near its bed than to contributions from more distant sources; Second Creek, perhaps, being the only stream from the left which materially adds to the volume of the river.

Third section.—This extends 67 miles and 779 yards, and includes a total descent of 762 feet to the surface of a natural basin below the Great Falls of Kanawha River, and it is the peculiar character of a portion of the valley included in this section which would present the most appalling difficulties to the construction of a canal.

For 45 miles, or to Bowyer's Ferry, obstacles, such as are almost continuous between Bowyer's Ferry and the Gauley River, are confined to but a comparatively small portion of the distance, but below Bowyer's Ferry it would be only at great expense that the canal could be protected against the impetuosity of a current almost resistless during the swollen stages of the river.

This is exemplified in the fact that freshets sometimes attain the great height of 35 and even 50 feet in some places, within whose utmost reach there could be no security to the durability of any work, and from the nature of the intermediate space between low-water mark and the cliffs, which rise nearly perpendicularly for several hundred feet; for notwithstanding, even below Bowyer's Ferry, there is generally room enough for the canal between low-water mark and the cliffs, and that the interval may never be wholly overflowed, it is occupied by masses of huge rocks exhibiting a surface almost too irregular to be defined. These rocks, however, may be converted into a kind of bench, on which the canal could be sustained beyond the reach of freshets, and eventually might facilitate its construction; but the necessity of high and extensive walling would still exist, and the total absence of any suitable material for puddling the canal would be irremediable except at the cost and trouble of procuring it from a distance, unless, indeed, clay of a proper consistency be obtained near the verge of the cliffs, when this latter source of expense may be very much diminished from the ease with which it might be deposited at convenient intervals along the line.

The rocks at the foot of the cliffs have every appearance of having at some period been precipitated from different points of the cliffs, and, although ages may have since elapsed, it must be obvious that it would be impossible to secure any work at the base of the cliffs against the destructive effects of a similar occurrence. It is not con-

*The Great Kanawha River is more familiarly known as New River above its confluence with the Gauley River.

ceived, however, that much importance is due to this suggestion, since there is little probability that such masses as those alluded to would in future be detached, unless by some extraordinary convulsion of nature beyond what we have reason to anticipate.

Above Bowyer's Ferry the valley is much wider, and, although the canal would frequently occupy steep slopes, such difficulties as exist below are not to be apprehended either from the heights of freshets or the perpendicularity of the banks. No trace was perceived of the water ever having risen more than thirteen feet above its ordinary channel until within a few miles of Bowyer's Ferry, and, with the exception of a few places designated by Lieutenant Hazzard as requiring walling to protect the canal, there is comparatively but little difficulty in sustaining the line beyond the reach of freshets.

The tributaries to New River, between Greenbrier and the Gauley Rivers, are few and unimportant; and the Great Falls of Kanawha, two miles below the Gauley, designates as well the commencement of an entirely different country from that above as the termination of our ideal section.

Tug Falls, Buffalo Falls, Richmond Falls, and the Great Falls, with an almost continuous rapid, when perpendicular falls do not occur—in all, constituting a spectacle the sublimity of which can scarcely be surpassed—characterize New River below its confluence with the Greenbrier as an impetuous and almost resistless torrent. And the general aspect of both sides of the river, with the wild features of its valley, can offer few temptations to the intrusion of civilized man. But the Great Kanawha majestically pursues its placid course through a rich and fertile valley, and is said to present but few obstructions to a perfect navigation from the falls to the Ohio River.

The general structure of the country below Greenbrier River is based on sandstone (gray and red) or a compact limestone, and *coal* of an excellent quality exists, in exhaustless quantities, from Sewell Mountain westward.

Having now sufficiently reviewed the several sections in detail, the following summary of the whole route will conclude the subject which has heretofore occupied us:

SUMMARY.

	Distance.		Lockage.
	Miles.	*Yards.*	*In feet.*
James River to the Greenbrier River	31	1,017	908
Thence to New River	49	151	297
Thence to the basin below the Great Falls	67	779	762
Total	148	187	1,967

ROANOKE AND KANAWHA CANAL.

On completing the surveys relating to a canal from James River to the Great Kanawha, those having reference to other objects enumerated in my instructions were immediately undertaken; and although a detailed report on the Roanoke and Kanawha Canal is unavoidably postponed till the drawings illustrative of the survey shall be more advanced, a brief summary of the more important facts may, at this time, be satisfactory, as it will suffice to show the great facility with which those rivers may be united.

The experimental surveys, which extended along the Alleghany Mountain, from the southern source of one of the branches of the North Fork of Roanoke, beyond Christiansburg on the north, to the South Fork of Elliot's Creek on the south, indicate the existence of frequent great depressions in the dividing ridge, or rather a general depression of the Alleghany Mountain, in its course between the waters of the Roanoke and those which, flowing westward, empty into Little River.

But the point which imposingly presents itself as offering superior advantages for the passage of the Allegheny by a canal is at the sources of the North Fork of Elliot's Creek, a tributary to the South Fork of Roanoke, and "Green Head Branch" of Meadow Creek, a tributary to Little River.

An abundant supply of water might be obtained from Little River, even were our summit-level of the same elevation as that of the very top of the mountain, in the depression alluded to; but apprised of that fact from the results of our experimental surveys, sufficient considerations recommended, notwithstanding, a location of the canal in the following manner:

The summit-level commences on the east side with a cut, which in 1,320 yards attains its greatest depth of 30 feet, (above the surface of the canal,) and terminating on the west side 144 yards beyond the end of the cut, includes, in all, 1,464 yards.

The canal then descends, through the valley of Meadow Creek, to Little River, and

thence along Little River to New River, under circumstances as favorable as might be expected, no difficulties occurring worthy of comment at this time; the distance from the summit-level to the latter point being 10 miles 769 yards, and the fall 28 feet.* From the mouth of Little River it is prolonged on the right bank of New River to its intersection with the James and Kanawha Canal; and to the mouth of Greenbrier, for most of the distance, the canal occupies very favorable ground through extensive flats which border on the river.

These flats, however, are not continuous, and frequently, for short distances, we must encounter cliffs which impinge upon the streams; but, with the remark that the difference is rather in favor of the valley of New River, we shall not create an erroneous impression if we refer to the location down the Greenbrier as the standard by which we may judge of that between Greenbrier and the mouth of Little River.

Returning to the summit-level, the descent on the eastern side, until we arrive within half a mile of the main valley of the North Fork of Elliot's Creek, is such as to necessitate a succession of short levels, and the canal falls, by locks of 8 feet lift, 120 feet in but 1 mile 485 yards; the next 11 miles 115 yards bring us to the mouth of Elliot's Creek, and comprise 62 levels and a descent of 496 feet; whence, through the wide and fertile valley of the South Fork of the Roanoke, the location extended to the forks, where the field-operations of the brigade terminated for the season.

The distance from the month of Elliot's Creek to the termination of the canal, near the forks of the Roanoke, is 9 miles 1,320 yards, and the fall 200 feet.† The canal, therefore, from the mouth of the Greenbrier River to the latter point, includes an ascent of 657.7 feet, in a distance of 94 miles 106 yards, (the distance from the Greenbrier to the mouth of Little River being 83 miles and 1,097 yards, and the rise 369.7 feet,) a summit-level of 1,464 yards, and a descent in 22 miles and 100 yards of 816 feet; or the total distance is 116 miles and 1,730 yards, and the lockage 1,473.7 feet.

SUPPLY OF WATER.

It is the great facility with which this is obtained that so distinctly characterizes the connection in view as one so very feasible in its execution. Little River, on which the summit-level is dependent, was found to yield at its lowest stage nearly 100 cubic feet per second, when its supply can be commanded by a feeder but 9 miles and 1,25 yards long.

Pilot Mountain, however, which lies between Little River and the summit-level, preserves such an elevated character, that the feeder can only pass it by a tunnel of 1 mile and 290 yards' length. We might, indeed, wind along the slope of the mountain, but it would so very greatly increase the length of the feeder, that there can be no hesitation in preferring a tunnel. In other respects, the construction of the feeder would be attended with little difficulty.

The supply from Little River alone would be ample to all the wants of the canal from New River to the forks of the Roanoke; but a reference to the report of Lieutenant Fessenden, which exhibits the discharge of the two branches of the Roanoke, of Elliott's Creek, of Meadow Creek, and the increased size of Little River, in its progress to its mouth, will show the abundance of its other resources.

Of the practicability, therefore, and comparative ease with which the Roanoke may be united to the Kanawha by means of a canal, the brief statement of facts which we have given will have been sufficient to dispel all doubt, and, on that conviction, we might forego all further discussion of the subject, but that a few other remarks naturally suggest themselves as neither uninteresting nor entirely irrelative.

If the connection be regarded merely as an avenue for the trade of the Ohio Valley, its importance in that light may doubtless, at some future day, elicit the effort to overcome those obstacles between Bowyer's Ferry and the Great Falls, which constitute almost the sole impediment to its comparatively easy execution. But should the magnitude of these obstacles be considered sufficient forever to discourage the enterprise of a nation, the importance of the connection, although diminished, is yet conspicuous. New River, for perhaps 100 miles above the mouth of Little River, it is said, traverses a country rich in mineral and agricultural products, and its navigation may prove easily susceptible of great improvement, while the direction of Reed Creek, a tributary of New River, above its confluence with Little River, is particularly spoken of as promising facilities for effectuating a connection with the Middle Fork of the Holstein.

Of this I cannot speak from personal observation, nor from information entirely authentic, yet the concurrent opinions of individuals acquainted with the country would

* The bench at the mouth of Little River, on the right bank, is 290 feet below the summit-level, and 16 feet above low-water mark.

† The bench-mark near the mill at the forks of the Roanoke is 831 feet below the summit-level.

seem to warrant a belief in the practicability of a canal from New River to the Holstein; and the relative situation of the Tennessee and Alabama Rivers, as delineated on every map, renders it by no means improbable that they, also, might be united. Thus it is possible, and I might even say within the scope of probability, that a canal from the Roanoke to the Kanawha may at some future day be regarded but as the last link in a chain of inland communication from the Gulf of Mexico to the Chesapeake.

From "a due investigation of the hydrography and topography of the country," it is certain that "no other routes" than those which have been described possess similar advantages for uniting either the James or Roanoke River with the Kanawha by means of a canal.

The country between Knapp's Creek, a branch of the Greenbrier, and Back Creek, a tributary to Jackson's River, and between Craig's Creek and Sinking Creek, opposite tributaries to Jackson's and New Rivers, was said to afford some facilities for a canal from the James to the Kanawha River, and was, in consequence, reconnoitered. But it is apparent that no route in either of those directions can present any claim to further examination, (see Lieutenant Dillahunty's report, page 800,) and the conclusion is equally obvious, from our present knowledge of the country, that the James River cannot be united by a canal with the waters of the Great Kanawha by any route below the valley of Dunlap's Creek, unless, indeed, as is highly probable, a canal from James River through the valley of Catawba Creek be found practicable to the Roanoke.

The examination, however, of the country intermediate to the Roanoke and James Rivers, with reference to a canal or railroad, is one of those objects enumerated in my instructions which as yet, from the want of time, have been omitted.

Of the practicability of a railroad from the James or Roanoke River to the Great Falls of Kanawha there cannot remain a doubt; and the surveys which have been made of the intermediate country will, in general, furnish ample means for deciding on the most proper routes. A single glance at the topography precludes all hesitation in selecting, for a railroad from James River, some one of the routes surveyed for a canal in preference to a more direct route over the high and numerous ridges which intervene between the Greenbrier and Gauley Rivers.

To be more explicit, however, with such deviations only as would result from the different characters of the two works, the route which has been adopted for a canal as far as the mouth of Muddy Creek would be pursued for a railroad. A doubt is suggested as to the best direction for continuing the route beyond that point only because it is possible that a route through the valley of Muddy Creek and across to Meadow River, a tributary to the Gauley (from the circumstance of there being but one ridge between Muddy Creek and Meadow River) may be found to possess advantages which may bring it in competition with a route through the valleys of Greenbrier and Kanawha Rivers.

But supposing it to pursue the same route as the canal, as is thought most probable, the length of a railroad from Covington to the Great Falls of Kanawha would be about 148 miles, with a rise and fall of 2,763 feet, on the supposition of passing the Alleghany without a tunnel.

The surveys from the Roanoke do not altogether determine the best route for a railroad to New River, beyond which it would, of course, continue down the valley. But the discovery that the Alleghany is nearly as low at one of the sources of the North Fork of the Roanoke near Christiansburg as on the route proposed for the canal, with the fact of the direction of the North Fork being such as to afford a shorter route than one up the valley of the South Fork, makes it more than probable that a railroad from the Roanoke would cross the Alleghany in the vicinity of Christiansburg.

However, whatever may be the deviation from our location of the canals by the substitution of railroads in their stead, they cannot be so material as to interfere with those general considerations which may determine, from what has now been stated, the comparative merits of railroads and canals as the means of uniting the James or Roanoke River with the Great Kanawha.

Having now briefly adverted to the operations of my brigade subsequent to the completion of the surveys relating to a canal from the James to the Kanawha River, in concluding this report I may be permitted to advert to the causes which have delayed its completion beyond the period at which the Department may have had reason to expect it. A report simply on the James and Kanawha Canal could have been presented at the commencement of the present session of Congress but for circumstances entirely unforeseen. I allude to the experimental surveys in relation to the Baltimore and Ohio Railroad, which were undertaken, with the assistance of my brigade, as late as the latter part of November and continued through a considerable portion of the inclemency of winter, when heretofore it has, in all cases, occurred that the maps and profiles illustrative of the operations of the summer-season have immediately succeeded our return to winter-quarters; and since the completion of those experimental surveys I have, from an impression that it would be more satisfactory to present an equally detailed report on both the James and Kanawha and Roanoke and Kanawha Canals alternately, employed myself, till within a few days only, on the former subject and on

a report on the Baltimore and Ohio Railroad, awaiting a more advanced state of the drawings to collate the facts essential to an equally detailed report on the Roanoke and Kanawha Canal. Time has not sufficed, however, to execute fully my intentions.

Which is most respectfully submitted by, sir, your very obedient servant,

WM. G. MCNEILL,
Captain United States Topographical Engineers.

TOPOGRAPHICAL OFFICE,
Georgetown, March 24, 1828.

APPENDIX.

CONTAINING REPORTS FROM LIEUTENANTS COOK AND HAZZARD, ILLUSTRATIVE OF THE LOCATION OF THE JAMES AND KANAWHA CANAL, WITH REPORTS FROM LIEUTENANTS DILLAHUNTY AND FESSENDEN ON THE SUPPLY OF WATER.

GEORGETOWN, D. C., *March* 10, 1828.

SIR: I herewith submit to you the results of those operations which, in compliance with your instructions of May 3, 1827, occupied the party under my command until those instructions were fulfilled. They relate to the location of a line of canal from Covington, on Jackson's River, to the Greenbrier River, by the route designated in your instructions to me, as well as the location of every work connected with it, such as feeders, reservoirs, dams, &c.

Dividing the line of canal into three parts, of which the first includes the summit-level, the second the portion east of it, and the third the descent to the Greenbrier River, I proceed to enumerate the details of each subdivision.

FIRST SUBDIVISION.

This includes a tunnel of 2 miles and 1,120 yards, two cuts of 50 feet each in depth and two basins; together constituting the summit-level, which comprises 4 miles and 789 yards. Its elevation is 694 feet above the base-mark. Further details in relation to this subdivision are omitted, because they have already been furnished you.

SECOND SUBDIVISION.

To avoid the constant repetition of facts which so frequently recur, a table has been formed to present at one view the details belonging to each level of this subdivision. To render it entirely intelligible, by the first level is meant that to which we descend from the summit-level by the first lock; the number of locks uniting adjacent levels refer to the number between each level and the one preceding; the length of the level is made to include the space occupied by the locks uniting it with the adjacent level. The length and height of acqueducts and culverts are in *feet*, length of walling in yards, and the height in feet above the bottom of the stream which it rests in.

Details belonging to each level of the second subdivision of the contemplated canal from Covington, on Jackson's River, to the Greenbrier River.

Number of level.	Length of level.		Number of locks.	Aqueducts.		Culverts.		Walling.		Slope of ground transverse to level.	Nature of excavation.	
				Length.	Height.	Length.	Height.	Length.	Height.		Soil.	Rock.
	Miles.	*Yards.*		*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Yards.*	*Feet.*	*Degrees.*		
1	0	140	1							16, 30	Sand and clay	Loose rocks.
2	0	295	2			6	4			17	do	Do.
3	0	152	1			6	4			17	do	
4	0	342	5			8	4			38	do	
5	0	143	1							38	do	
6	0	124	1							33	do	
7	0	160	1							38	do	Rock.
8	0	185	2			6	4			35	do	Loose rocks.
9	0	140	1			6	4			35	do	Do.
10	0	140	1			6	4			35	do	Do.
11	0	293	4							33, 35	do	Rock.
12	0	155	1			6	4			29	do	Loose rocks.
13	0	243	1							29	do	Do.
14	0	153	1							29	do	
15	0	163	1							12	do	Loose rocks.
16	0	153	1							12	do	Do.
17	0	120	1							12	do	Do.
18	0	196	2							38	do	Do.
19	0	300	1	20	8					Flat	do	
20	0	133	1							do	do	
21	0	194	1							do	do	
22	0	167	1							do	do	
23	0	465	2	20	15					Flat, 20, 18	do	
24	0	325	1							18, 40	do	
25	0	160	1							40, 20	do	
26	0	153	1			6	4			21	do	
27	0	153	1							21	do	
28	0	153	1							Flat	do	
29	0	834	1							do	do	
30	0	443	1							do	do	
31	1	0	1	60	10	6	4			do	do	
32	0	690	1			6 6	4 4			2, 6	do	
33	0	706	1			6 6	4 4			6, 17	do	
34	0	1,251	1			6 6	4 4			36, 24, 5	do	
35	0	210	2			6	4			32	do	
36	0	176	1							Flat	do	
37	0	204	2			6	4			do	do	
38	0	1,350	1			6	4			do	do	
39	0	146	1							do	do	
40	0	710	1			6	4			19, 30, flat	do	

Details belonging to each level of the second subdivision of the contemplated canal from Corington, &c.—Continued.

Number of level.	Length of level.		Number of locks.	Aqueducts.		Culverts.		Walling.		Slope of ground transverse to level.	Nature of excavation.	
				Length.	Height.	Length.	Height.	Length.	Height.		Soil.	Rock.
	Miles.	*Yards.*		*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Yards.*	*Feet.*	*Degrees.*		
41	0	170	1							Flat	Sand and clay	
42	0	1,000	1							Flat, 26	do	
43	0	356	1			6	4			Flat	do	
44	0	155	1							do	do	
45	0	337	1							do	do	
46	0	690	1			6	4	170	11	Flat, 44	do	Rock.
47	0	440	1			6	4			44, 5, flat	do	Loose rock.
48	0	700	1			6 6 6 6 6	4 4 4 4 4	80	13	Flat, 44, 30, 2	do	Do.
49	0	164	1			6	4			2	do	
50	0	164	1							2	do	
51	0	760	1					315	18	45, flat	do	Rock, loose.
52	0	627	1	80	12	6 6	4 4			Flat	do	
53	0	546	1							do	do	
54	0	400	1			6	4			do	do	
55	0	666	1							do	do	
56	0	870	1			6	4			do	do	
57	0	1,700	1	60	13					17, flat, 10, 28	do	
58	0	149	1							28	do	Loose rock.
59	0	150	1							28	do	Do.
60	0	140	1							28	do	Do.
61	0	190	1							28	do	Do.
62	1	464	1	75 75	10 18	8	4			Flat, 17, flat	do	Rock and loose rock.
63	0	217	1							27	do	
64	0	206	1			6	4			27	do	
65	0	343	1			6	4			Flat	do	
66	0	360	1							3	do	
67	0	280	1			6	4			3	do	
68	0	264	1			6	4			3	do	
69	0	150	1							3	do	
70	0	989	1					390	17	Flat, 48, flat	do	
71	0	1,254	2			6	4	175	15	19, flat, 50	do	
72	0	1,024	1			6	4	220	15	Flat, 50, flat	do	Rock.
73	0	70	*1							Flat	do	

* Of 12 feet.

From the foregoing table it may seem that some objectionable features attend the location of the canal, such as the occurrence of contiguous locks in five places, the crossing of Fork Run and Dunlap's Creek by aqueducts, and the deep cuttings in the sixty-second level. The reasons which influence me in each instance will therefore be detailed. The levels along Fork Run, from the descent of its valley, necessarily had to be very short. The length of the first level was greater than could have been the average by single locks, and, to avoid contiguous locks, on that account alone we should have terminated it. But a single lock would have brought the next level in contact with unfavorable ground, necessitating either a circuitous route around a ravine or an embankment across it; and, to diminish the difficulty, we descended at once by two locks.

At the end of the third level the same reasons for five contiguous locks obtained, but to a greater degree; the ground was exceedingly steep at the elevation at which we were above the stream, and a wider and deeper ravine was before us.

The seventh level was terminated by two contiguous locks, that the eighth level might occupy the most favorable ground, and the tenth level was terminated by four contiguous locks to avoid a high and precipitous cliff of sandstone.

Thus far the left shore was the preferable one, but thence to the mouth of Fork Run the right was decidedly better, because of the frequent occurrence on the left shore of steep and rocky ground. We therefore, on arriving at the end of the tenth level, descended, in order to cross as soon as possible; and to do so with the shortest and lowest aqueduct, we resorted to two locks. In the valley of Dunlap's Creek the descent from an upper to a lower level is only in three places effected by two contiguous locks. In the first two cases it was to shorten the distance to avoid very steep ground and to take advantage of very favorable flats. In the last case it was to diminish the height of walling necessary to pass the cliff, which occurs in the seventy-first level.

The reasons for crossing Fork Run in the nineteenth level have been already given in the second instance near the mouth. It was crossed to save the distance to a favorable point for crossing Dunlap's Creek above the mouth of Fork Run, to say nothing of the ground on the left shore of Dunlap's Creek being decidedly preferable to that on the right for nearly 2 miles.

Dunlap's Creek was then crossed, because the expense of crossing Brush Creek, Lick Creek, and sundry smaller runs which enter on the left, would, in itself, have been more than the expense of crossing and even recrossing Dunlap's Creek; and, besides, the ground on the right for more than 5 miles was known to be much better than that on the left.

The canal subsequently crosses Dunlap's Creek four times in its progress to the mouth of the creek. The high and extensive cliffs which occur on the right shore between the fifth and seventh miles, it was thought, entitled the left shore to the preference during that distance; but the entrance of Ogley's Creek just below the fifth mile, and the continuance of very steep and rocky ground on the left, again renders it expedient to gain the right shore.

The last two crossings of the creek are incurred rather than wind around the bend of the stream, on the right of which there is a deep ravine, and very steep and rocky ground: and as, agreeably to your instructions, the canal was, if practicable, to follow nearly the direction of the turnpike beyond that bend, one crossing, to avoid the rocky ground alluded to, necessitated another to conform to your instructions, since it was found practicable and altogether more expedient to follow the direction of the turnpike than the very circuitous course of the creek. In evidence of this fact the alternative, which is preferred, of crossing in the depression through which the turnpike is located, instead of following the valley of Dunlap's Creek, saves one thousand and thirty-three yards of canal along very unfavorable ground; at the expense, however, of the deep cut in the sixty-second level.

As to the termination of this subdivision, you remark in your instructions to me, "Since it may reasonably be expected that, if ever a canal be made across the Alleghany Mountains to James River by the route to be surveyed, it would be continued down the river, or the navigation of the river would be so far improved as to admit the passage of boats such as would be adapted to the canal, you will, to provide for either contingency, so conclude your survey on reaching James River that the length and height of an aqueduct to reach Covington may be determined, (as in the event of a continuation of the canal it is through that town that the chief engineer of Virginia has recommended its location,) besides so locating it that in the event of its termination on this side, and the improvement of the navigation of the river by locks and dams, the lockage, &c., may be drawn to a basin on such a level as would be formed by the construction of a dam of some moderate elevation."

The location exhibited by the profile of the canal refers to the latter supposition, and the descent from the last level to the surface of a basin formed by a dam 8 feet high, two hundred and seventeen yards below the mouth of Dunlap's Creek, is supposed to be effected by a lock of 12 feet lift. The length of the dam is 300 feet.

On the supposition of an aqueduct to cross to the town of Covington, in order to admit the requisite thickness to the arches and be beyond the reach of freshets, (which rise from 5 to 10 feet,) the seventy-first level should be continued across the river; the length of that level would be one mile and eight hundred and thirty-five yards, including an aqueduct 300 feet long and 21 feet high, counting from the bottom of the stream.

The heights of freshets in Dunlap's Creek vary, of course, with the fall and width of the stream, but they may be said to rise from 5 to 7 feet at most. The general depth of the stream is so trifling that only the low-water mark has been represented on the profile; the height of aqueducts, walling, &c., is, however, counted from the bottom of the stream.

On reaching the valley of Dunlap's Creek, those considerations obtained which you directed in reference to the introduction of a supply of water from Dunlap's Creek without "the risk of inundation from freshets," the canal was dropped "so as to require but a short feeder from a suitable site for a dam of moderate elevation." The section of a dam on an enlarged scale is given on the map; the length of the feeder is but 610 yards.

THIRD SUBDIVISION.

From the western end of the summit-level to bench-mark on the Greenbrier River. To this subdivision there is a table annexed, to comprehend precisely such facts as are contained in the table connected with the second subdivision.

Number of level.	Length of level.		Number of locks.	Aqueducts.		Culverts.		Walling.		Slope of ground transverse to level.	Nature of excavation.	
				Length.	Height.	Length.	Height.	Length.	Height.		Soil.	Rock.
	Miles.	*Yards.*		*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*			
1	0	180	1							Flat	Sand and clay	Loose rock.
2	0	167	1			6	4			do	do	Do.
3	0	693	1			6	4			do	do	
4	0	173	1							do	do	
5	0	167	1							do	do	
6	0	825	1	45		6	4			Flat, 17° 30′ flat.	do	
7	0	330	1			6	4			Flat	do	
8	0	166	1							do	do	
9	0	433	1							do	do	
10	0	963	1	50						do	do	
11	0	256	1			6	4			do	do	
12	0	227	1			6	4			do	do	
13	0	740	1			6	4			do	do	
14	0	790	1			8 6 8 6	4 4 4 4			Flat, 23° 30′	do	
15	0	360	1							23° 30′	do	
16	0	983	1			8 6	4 4			Flat	do	Loose rock.
17	0	370	1							24°, flat	do	
18	0	576	1			6	4			Flat	do	
19	0	1,217	1			6 6	4 4			Flat, 24°, 28°, 49°, 26°	do	Loose rock.
20	0	164	1							43°, 27°	do	
21	0	466	1					107	15	27°, 35°, 50°	do	Loose rock.
22	0	406	1							35°, flat	do	
23	0	633	1							35°, near flat	do	Rock, loose rock.
24	0	743	1							do	do	
25	0	710	1			6	4			Flat, 25°	do	
26	0	227	1			6	4			Flat	do	
27	0	1,270	1					125	19	Flat, 25°, 20°, 7°, 25°	do	Earth.

The foregoing table, with the map and profile, showing the location, renders it unnecessary to dwell long on this subdivision.

The reasons for first crossing the creek when it had been determined to cross the Greenbrier River from the right bank of Howard's Creek were simply because the distance was diminished and more favorable ground obtained on the left side; and had we not considered these and remained on the right shore our line would have been obliged to cross the Middle and North Forks of Howard's Creek.

In the ninth and tenth levels the canal four times crossed a channel occupied by a part of the stream in time of freshets, but the stream may easily be confined to the main channel by a short dike, and therefore it was not considered an objection to the location.

We recrossed the creek in the tenth level for similar reasons; that is, to shorten the distance, &c., because, as we just now observed, the Greenbrier was to be crossed above the mouth of Howard's Creek.

In the eighteenth level we unavoidably cross the turnpike, and it may be as well to remark that the transverse slope along the nineteenth level, although represented very steep, is terminated by a flat not more than about fifteen feet above the canal; and the cutting represented at the end of the level is the height of a point of bottom-land which we cross because of the precipitous slope of the ground near the creek.

The walling is nowhere very considerable, and where it has occurred it was unavoidable.

In general, it may be remarked that the canal occupies very favorable ground throughout this subdivision.

On arriving at the bench-mark designated as the termination of this subdivision, and which is 3 feet below the bottom of the canal at the last level, a feeder was run up the river on the supposition that an additional supply of water might be required. This it was found can be accomplished by a feeder 1,260 yards long through the most favorable cutting, and a dam across the Greenbrier of 108 yards in length and 13 feet high.

The feeder intended to introduce a supply from Greenbrier River into the canal was located from the western end of the summit-level, at an inclination of 6 inches per mile, until it intersects the Greenbrier River, or, rather, until a dam 5 feet high was required to turn the water into the feeder. The length of the feeder, by the route surveyed, is 31 miles 130 yards, but as it includes a tunnel of 5 miles and 200 yards through the spur of the Alleghany Mountain, which divides Howard's from Anthony's Creek, our reasons for not surveying the route, also, around that spur, as you directed, will be given.

We shall divide the feeder into such portions that the first and third will include the parts which would be common to both routes; and the second portion, including the tunnel, will then compare directly with that part around the spur, from the end of the first to the beginning of the third part.

The first section pursues a level along pretty favorable ground, with the exception of two or three places where deep cuts for short distances must be encountered from the summit-level to within but a short distance of the tunnel, and includes 4 miles and 396 yards.

The second section continues on a level but 100 yards, when 1,497 yards are occupied by the two cuts, which are supposed to terminate at 35 feet depth at either end of the tunnel; that is, the cut on the southern side is 1,187 yards long, the tunnel 5 miles 200 yards, and the northern cut 310 yards long; the remainder of this section extends but 740 yards farther to the aqueduct over Anthony's Creek; making the length of the second section 6 miles 747 yards.

Now, suppose, instead of tunneling through this spur of the mountain, we follow the level, and see what objections there are to this location.

From the end of the first section, the level was continued with the intention to pursue it until we should arrive, as we did by the route through the spur, at the first favorable point for crossing Anthony's Creek; but an experiment of but 10 miles over what we knew was a fair specimen of the remainder induced us to suppose that, had you been present, you would have considered it, as we did, useless to proceed farther. The spur is indented on both sides by innumerable ravines, bounding the small branches tributary to Howard's Creek or the Greenbrier River; and, as a proof of the great variation from anything like a tolerably direct course necessitated by those ravines, while, by the route of the feeder, following the proper level or inclination, the distance is 10 miles, between the same points, by the road through the valley, the distance is but 5 miles.

We know, by former surveys of last year through the valleys of Howard's Creek, the Greenbrier River, and Anthony's Creek, from the point where we terminated our experiment to the point at which we should be obliged to ascend Anthony's Creek to cross it, the distance could not be less than 21 miles. But these 21 miles pass over ground no more favorable than was that which we had found to double the distance beyond what, by the same standard, without an actual location, we should have consid-

ered it. We might, therefore, with little risk of magnifying the length of feeder by this route, add at least one-third to the 21 miles, and thus make the saving of distance by the tunnel 32 miles. This excessive length, however, would not alone have deterred us; but, knowing as we did that almost throughout these 32 miles the feeder would pass over very steep ground, varying from 25° to 45°, we concluded the losses of such a feeder, so situated, would certainly leave a supply altogether inadequate to the wants of the canal; or, in fact, we concluded the other was the only practicable route. It was this conclusion which determined us to improve the means at our disposal in the execution of surveys which it was known to be desirable, if possible, to finish before the close of the season.

The third section includes the remainder of the feeder. It begins with the aqueduct across Anthony's Creek, which is 40 feet high and 120 yards long. Different experiments were made to ascertain the most favorable place for crossing this creek at a less elevation above its bed. In one case, with an aqueduct of 32 feet high and 170 yards long, it increases the length of the feeder 1 mile; and in another, still higher up, with an aqueduct 20 feet high and 133 yards long, the distance was increased to 3 miles 342 yards. The site at last adopted was that at the point lowest down the creek, being the best that could be found.

At 487 yards beyond the aqueduct we arrive at the end of the eleventh mile from the summit-level, and all that relates to the remaining part of the feeder will be found contained in the following table:

TABLE.

Number of miles.	Tunnel's length.		Aqueducts.		Culverts.		Walling.		Slope of ground transverse to feeder.	Nature of excavation.	
			Length.	Height.	Length.	Height.	Length.	Height.		Soil.	Rocks.
	Miles.	*Yards.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Degrees.*		
12									28, 35, 26, 34	Clay	Loose rocks.
13	1	215			6	4			34, 30, 12, 30	do	Do.
14					6 8	4 4			30, 26, 20, 34, 19	do	Do.
15									19, 30, 42, 30, 20, 42, 60, 28	do	Do.
16					6	4			28, 34	do	Do.
17	1	190							34, 40, 33, 40, 34	do	Do.
18					6 6	4 4			34, 35, 45	do	Rock and loose rock.
19					6 6	4 4			45, 35, 50, 35, 30, 35	do	Do.
20					6 6	4 4	300	30	41, 43, 33, 44, 20, 31, 43	do	Do.
21					6 6 6	4 4 4	200	10	43, 31, 20, 31, 34	do	Do.
22					6 6 6	4 4 4			34, 25	do	
23					6	4			25, 38, 23	do	Rock and loose rock.
24					10	6			23, 0', 23, 0', 32	do	Loose rock.
25					6 6 6	4 4 4			32, 38, 21	do	Do.
26					6 6	4 4			21, 58, 40, 50, 45, 40, 35, 30	do	Do.
27					10 6 6 6	6 4 4 4			30, 26, 2, 28	do	Do.
28									28, 26, 43, 35, 28, 4, 2	do	Do.
29					6	4			5, 7, 45	do	Rock and loose rock.
30					6	4			45, 50, 30, 35, 40, 35	do	Do.
31					6	4			3, 5, flat	do	Loose rock.

A reference to the foregoing table shows, as the most unfavorable feature of that part of the feeder between Anthony's Creek and its termination, the steep slope along which it necessarily is located; nor did it seem but that this difficulty would be rather increased than diminished by keeping a higher level. The two tunnels which occur in the 13th and 17th miles are particularly recommended, in preference to the circuitous course we should pursue in following the level around those points through which we tunnel. For, omitting any cutting at either end of those tunnels in the one case, while the distance through is but 21 yards, the distance around is 2 miles 1,000 yards, over very rocky and precipitous ground; and, in the second case, the tunnel is but 190 yards, and the distance around 1 mile 738 yards, over very unfavorable ground. It will be seen that limestone is but very seldom crossed by the feeder; generally speaking, a compact sandstone is found; rock-excavation will occur in but few places; loose rocks, however, are along a great part of the line, beneath which there is a clayey and gravelly soil. When walling is mentioned, it is supposed necessary on account of the perpendicular cliffs; it, however, may prove better to blast the rock in such places, so as to obtain sufficient width for the feeder without walling.

The dimensions of a dam sufficiently high to turn the water into the feeder will be seen better from the map; its greatest height—for it crosses an island—is 5 feet, and its length is 120 yards, including 30 yards for the width of the island. The position of the dam for the reservoir to be formed was chosen 285 yards above the low dam just spoken of, where the valley is very narrow and the sides composed of rock. It might be raised to almost any height, and the relative lengths of dams of 30, 50, 60, and 70 feet high are as follows, (referred to on p. 773):

Dam 30 feet high; length at bottom, 70 yards; ditto at top, 132 yards.
Dam 50 feet high; length at bottom, 70 yards; ditto at top, 195 yards.
Dam 60 feet high; length at bottom, 70 yards; ditto at top, 212 yards.
Dam 70 feet high; length at bottom, 70 yards; ditto at top, 228 yards.

The area and prism of each are given below:

Dam 30 feet high; area, 623,155 square yards; prism, 2,596,636 cubic yards.
Dam 50 feet high; area, 1,278,400 square yards; prism, 8,578,148 cubic yards.
Dam 60 feet high; area, 1,737,162 square yards; prism, 14,000,000 cubic yards.
Dam 70 feet high; area, 2,191,046 square yards; prism, 21,000,000 cubic yards.

The site of the dam selected the first year, in making the experimental surveys, was higher up the river, (720 feet above the base-mark,) but it would overflow a much greater area in proportion to the cubic contents of the reservoir.

In every case, however, where there was occasion for the discretionary exercise of judgment in the execution of the duties assigned to Lieutenant Fessenden and myself, the alternative to the course adopted by us was never rejected without our concurrent opinion that its comparative advantages could not bring it hereafter in competition.

A report of the other objects (the railroad from Covington to the Greenbrier River, and the connection of the Roanoke and Kanawha) which subsequently occupied the party under me is delayed until the drawings shall be more advanced.

I am, sir, very respectfully, your obedient servant,

WILLIAM COOK,
Lieutenant United States Artillery, on Topographical Duty.

Capt. WM. G. MCNEILL,
United States Topographical Engineers, Georgetown, D. C.

GEORGETOWN, *March* 20, 1828.

To Capt. W. G. MCNEILL:

SIR: By the arrangements of the duties of the field for the season, the party destined to examine and locate a line of canal or railway from the mouth of Howard's Creek, down the Greenbrier and Kanawha Rivers, to the foot of the Great Falls of Kanawha, having been placed under my direction. I have now the honor of submitting a report upon the operations which occupied me during the summer.

Early in the season the leveling and survey commenced at the mouth of Howard's Creek, and was continued, without intermission, down Greenbrier River to its intersection with Kanawha or New River, and from thence to the foot of the Great Falls.

Returning to the mouth of Greenbrier River, a line of canal was examined from thence to the mouth of Little River. This is regarded as a portion of the Roanoke and Kanawha Canal.

In describing the line as located down Greenbrier and Kanawha Rivers, three divisions are made:

1st. From the mouth of Howard's Creek to the mouth of Greenbrier River.
2d. From the mouth of Greenbrier River to Bowyer's Ferry, (on Kanawha.)
3d. From Bowyer's Ferry to the foot of the Great Falls.

FIRST SUBDIVISION.

Greenbrier River presents those characteristics which are peculiar to streams having their principal sources in the elevated regions of the Alleghany Mountains. In pursuing and forcing its circuitous passage through the many ridges of mountains that are intersected, it is frequently confined within very narrow limits, and in such cases it is invariably bounded by steep, rugged, and often precipitous banks. At other points the hills gradually recede from the river, and rich flats appear, which offer every facility for the construction of works of art.

To obtain minutely every feature of the valley, and thereby insure a judicious selection of that side along which a line of canal might be most advantageously located, it was thought expedient to examine carefully both banks of the river. From the facts thus accurately developed, it will be seen that the right bank is decidedly to be preferred, both from its features being generally more favorable, and from its southern exposure.

In many instances, where bluffs are met with on one bank, more favorable ground might be found on the other.

But as the river is remarkably serpentine in its course and cliffs occur at every bend—generally on the concave side—little or no advantage in any one instance would be gained by crossing.

The first level of the first subdivision commences on the right bank of the river at the point (*a*) on the map, 16 feet above low-water mark.

The space, 350 yards, included between this point and the termination on the left bank of the canal-line down Howard's Creek, is occupied by two locks, an aqueduct, and a small portion of canal.

The highest freshets on Greenbrier average from 9 to 13 feet; in one or two instances it has been known to exceed 15 feet, but this rarely occurs.

In order that the aqueduct may be placed entirely beyond the reach of the highest freshets, and the quantity of drift-wood and ice which is brought down during the winter, the water-line is supposed 33 feet above low-water mark. The length of the aqueduct is 167 yards.

To descend from this level to the level of the first section, two locks of 8½ feet lift are required.

A supply of water taken from the Greenbrier River at a suitable point above may be received at the commencement of the first level under the most favorable circumstances.

In order to avoid a tedious repetition of the same facts, which continually recur, a table is attached, exhibiting the length of each level, the number of culverts required, the extent and height of walls, and the general character of the ground.

As far as it has been practicable, the line of canal has been located at the foot of the hill-slope, about 15 feet above the surface of the water. This position is recommended by the greater uniformity which it offers in excavation and the greater facility with which any given level may be retained.

From the first to the end of the fifth level no material difficulty is met with. The line is traced alternately through flats, generally narrow, but wide enough for all practical purposes, and along the river-bank, often rocky and steep. The streams which are crossed are generally small mountain-drains, which yield during the summer months little or no water. The quantity, however, of stone and gravel which is brought down by the current after heavy rains renders it advisable, in most cases, to pass them under the canal through small culverts.

At the beginning of the sixth level the line intersects rugged cliffs of limestone, to sustain the level of the canal, along which a wall 863 yards in length and 20 feet high is required. Its construction is facilitated by the suitableness of the stone on the spot and the ease with which its base may be placed below low-water mark. The water along the right bank, though rapid, is generally shallow. From thence to the end of the seventh level the ground is quite favorable.

In the eighth level perpendicular cliffs of limestone again occur. The water at the base of these cliffs is deep and rapid. Near the end of this level the line crosses Mill Creek by means of an aqueduct 100 feet in length and 17 feet above the water. This stream is remarkable from the singular fact of its disappearing entirely 9 or 10 miles from its mouth, and, after flowing in a subterraneous channel through this distance, it suddenly gushes up in a ravine at the foot of high perpendicular cliffs, and soon after puts in operation a mill, which is kept in motion by it throughout the driest seasons.

A short distance below the mouth of Mill Creek this level is again embarrassed by cliffs of limestone, requiring a wall. Opposite this point a long rapid commences, and a suitable point may be found for a dam; one 8 or 9 feet high, and a feeder 946 yards in length, would furnish a fresh supply of water at the commencement of the tenth level. Early in this level vertical cliffs of limestone are met with, which will require a strong wall, having its base generally beneath low-water mark; water along the base deep and rapid.

From thence for some distance the ground is favorable. Toward the end of the level the line intersects Muddy Creek Mountain, along the declivity of which the canal necessarily occupies very unfavorable ground. The general slope averages 18°, and is covered for the most part with fragments of sandstone and conglomerate rocks.

About the beginning of the fourteenth level the mountain recedes from the river, and the line occupies a very favorable flat until it intersects Muddy Creek. This creek is crossed by a small aqueduct 50 feet in length and 19 feet above the water.

The quantity of water which Muddy Creek yields during the summer months is quite small. Should its supply, however, ever be required, it might easily be thrown into the canal by a moderate dam and a short feeder.

From hence through the sixteenth, part of the seventeenth, eighteenth, and part of the nineteenth level the line is traced along a hill-slope, frequently steep and rocky. Several culverts are required and some walling, the extent of which is shown in the table. Through the remainder of the nineteeth level the nature of the soil admits of easy excavation.

Through the twentieth and part of the twenty-first level the line occupies a very unfavorable position along a steep and rocky hill-slope. From B. M. No. 20 to the end of the last level, with the exception of a straight wall along cliffs of red sandstone, the ground is generally quite favorable.

In the twenty-second level, Hunger's Creek is crossed by an aqueduct 50 feet in length and 17.5 feet in height, with an embankment at either extremity of 50 feet. This stream discharges a quantity of water in wet seasons, but during the summer months it nearly goes dry. The deep cutting along this level is very considerable, owing to the general steepness of the hill-slope along which it is located. Toward the end of this level the river suddenly turns from a southeasterly to a northwesterly direction, forming thereby Stricker's Neck. On the east side of this bend, cliffs of compact sandstone rise vertically from the water. This point presents a greater obstacle than we have yet encountered. The most unfavorable portion extends 266 yards; in this distance the river descends 10 feet, and the whole course of an impetuous current is concentrated at this point. The base of the wall required here must unavoidably be placed beneathed low-water mark, in deep and rapid water, and should be formed of the strongest materials, to resist the powerful pressure to which it will be exposed during a freshet.

No opportunity is offered of avoiding this difficulty by crossing the river, as cliffs of an equally unfavorable nature present themselves on the left bank.

The profile is the development of the line around this point. The distance, however, may be lessened more than half a mile, and this obstacle avoided, by tunneling 133 yards through this neck, or by a deep cut 76 feet. The point alluded to is contained between the letters *x* and *y* on the map and profile.

Through the next five and part of the sixth levels the canal must also be supported in a great measure by a strong wall, having its base frequently beneath low-water mark.

From the middle of the twenty-eighth to the thirty-fifth level the ground is generally favorable, with the exception of one or two points, at which the hill-slope becomes steep and rocky. In this distance numerous small streams are crossed, which will require, for the reasons given above, small culverts.

About the middle of the thirty-fifth level rugged cliffs of sandstone are encountered. The river here is wide and shallow, with little fall. About the beginning of the thirty-sixth level, the line gradually curves along the base of the hill, and finally gains the wide valley of Kanawha River. The first subdivision is supposed to end at B. M. No. 28, near the commencement of the thirty-sixth level, and opposite the mouth of Greenbrier River.

Length of the first division, 48 miles 1,561 yards; fall in the river, 287.52 feet.

SECOND SUBDIVISION.

The valley of Kanawha River presents, in a great measure, the same characteristics as that of Greenbrier River. Probably there is not another stream in the country, of equal size, which furnishes less bottom-land along its banks, and which receives so few tributary streams of any size. The flats which are found are generally so narrow and occur so seldom that the valley is, comparatively, a perfect wilderness. The numerous rapids and falls, which are met in nearly every mile, form a striking feature of this river. The bed of the stream being very wide, and the water allowed in most cases to flow off freely, the freshets seldom exceed 13 feet.

Although the soil of the flats is generally light and sandy, the hill-slopes are usually covered with a thick growth of fine timber, such as the poplar, the beech, maple, white and red oak, and some pine trees.

The numbers of the levels are supposed to continue from the commencement of the first division.

From the commencement, then, of this division to the end of the thirty-seventh level the line passes through a sandy flat, offering but little impediment. Through

the next two levels, the declivity of the hill being steep and rocky, some embankments and walling are required. The extent and height of each is exhibited in the table.

Opposite the last level the stream descends, in a few yards, 13 feet, forming what is called "Tug Falls." The river at the head of this fall is rather wide; in every other respect it presents a very favorable site for a dam. From hence, through the next five levels, the line meets with no obstructions. In the forty-second level Brooks's Falls is passed. The river is here 293 yards in width, and descends 9 feet over a ledge of rocks extending from bank to bank. This is a more favorable point for furnishing the canal with a new supply of water than the one noticed above. A dam 8 or 9 feet high, and a feeder less than half a mile in length, would effect this object. In the forty-fifth level the line intersects the cliffs just above Richmond's Falls. This fall is a very prominent feature of the river, and the obstacles here, on the right bank, are of the most serious nature. The river descends perpendicularly over a ledge of rocks 23 feet high, and is bounded on either side by high vertical cliffs of compact sandstone. On the right bank the cliffs commence some yards above the falls, and extend through the forty-sixth and part of the forty-seventh level; in all which distance the bed of the canal must necessarily be upheld by a high and strong wall.

On the left bank the same rude cliffs extend for some distance above. Immediately, however, at the falls a small flat occurs, which offers greater facilities for the construction of locks, &c. At the termination of this flat the bluffs again present their hideous front, and the left bank then becomes as unfavorable as the opposite one. Hence, the idea of crossing the river to avoid the great difficulty immediately at the falls is precluded by the simple fact that the obstacles on the left bank, both above and below, are equally great. Through the remainder of the forty-seventh level the line occupies a narrow, sandy flat. For the next mile and a half, in the forty-eighth level, the hill-slope is steep and rocky; this is again succeeded by a favorable flat, which continues to the end. In crossing the valley of Meadow River, the embankment is greatly increased, owing to the necessity of retaining the level high enough to place the canal above the reach of the high freshets to which this small stream is subjected, as indicated by the quantity of drift-wood collected on the flat at its mouth. Aqueduct, 33 yards in length and 14 feet high. Through the next nine levels the canal is generally located along sloping ground, varying from two to twenty-three degrees. In two instances some embankment and walling are required.

In the fifty-ninth level Laurel Creek is passed. About a quarter of a mile above the mouth this creek forks, and discharges its water into the Kanawha through three different channels. A small dam at the forks would throw the water into one channel and save the expense of two culverts. This level, after passing through a sandy flat, encounters a very rugged hill-slope, along which a strong wall must be constructed. Owing to the sudden bend which the river here makes, the right bank is exposed to the full force, during high tides, of an impetuous current. Through the remainder of this level and the next the ground is more favorable, sloping from one to 10°. From hence to the end of the seventy-first level the canal is located, for the most part, along a steep and rocky hill-slope. The degrees of declivity, given in the profile, along each level will show in each case the extent of deep cutting. The table will also exhibit the length and height of each portion of walling. Opposite the end of the sixty-fifth level the river descends 11 feet in a few yards, and a favorable site may be found for a dam. To receive this fresh supply of water, the level of the canal is lowered by two locks, with a basin intervening, of 171 yards. Owing to the bed of the stream being here very much contracted, the height of freshets is unusually great. The wall, therefore, required to support the bed of the canal along this portion of the line must be at least 27 feet high, and calculated to resist the pressure of the immense body of water which rushes by during high tides.

From the seventy-second level to Bowyer's Ferry the ground is generally unfavorable. In a few instances the line passes through narrow flats, but generally along the hill-slope, which is frequently steep and rocky. Near the beginning of the eighty-fourth level a suitable site occurs for the erection of a dam. A fresh supply of water is thought of thus early, from the circumstances that no convenient site for a dam is found between this point and the end of the line; and the canal could not be lowered below this without materially jeopardizing its safety. The second subdivision is supposed to end at Bowyer's Ferry.

Length of this division, 45 miles 901 yards. Total fall in the river, 399.415 feet.

THIRD SUBDIVISION.

From Bowyer's Ferry to within 2 miles of the Great Falls the valley of Kanawha presents a novel and frightful appearance, and the obstacles that are met with are decidedly more formidable than any that have even yet been encountered and overcome. The river here breaks through Sewell Mountain, and is confined throughout within narrow limits, bounded by rugged banks and precipitous cliffs, rising many hundred feet above the surface of the water.

Immense masses of rocks, which have been ejected from the cliffs near the brow of

the mountain, cover the lower slope on both sides of the valley, giving to the whole a most appalling appearance. In many instances these huge fragments have been precipitated entirely across the bed of the stream. In such places the river when agitated and swollen by heavy rains—the current being obstructed in its course—frequently rises from 35 to 50 feet above its usual height.

Numerous rapids and falls occur, over which the water rushes with deafening impetuosity.

From this faint account of the general character of this portion of the route, it will immediately be seen that the bed of a canal must unavoidably be supported throughout the whole distance by a high wall, capable of resisting the immense pressure to which it must necessarily be exposed from the impinging of this furious current.

There is generally sufficient space (with the exception of three or four points noticed in the profiles, when the cliffs rise vertically from the surface of the stream) between low-water mark and the bluffs for the construction of such a wall. This space, however, is usually occupied by the immense masses of rocks alluded to above.

In all this distance there is but one small flat; hence, the want of materials on the spot for puddling the bottom and sides of the canal will be very seriously felt.

In making the survey every feature of the valley was so carefully observed that, in case a canal along this portion of the route should be thought inexpedient, from the unusually great expense which would attend its construction, a railroad might be substituted along the same line, with such alterations as might be suggested by the data now in our possession. This, however, must hereafter form the subject of a separate report.

About half a mile above the mouth of Gauley River the line gains a narrow flat, along which it continues until it crosses the river by an aqueduct 23 feet above the surface of the stream and 213 yards in length.

From hence to the Great Falls of Kanawha the line occupies a favorable flat.

To descend from the level of the last section to the surface of the water at the foot of the Great Falls four locks of 9.8 feet lift are required.

A ledge of rocks, extending diagonally across the river and over which the stream descends perpendicularly 21 feet, forms what is known as the Great Falls of Kanawha. The main body of water passes through a sluice about 100 yards in width near the left bank. The remainder of the ledge is only covered at high tide.

Just below the falls there is a most beautiful natural harbor, the river being here 650 yards in width and 10 to 15 feet deep within a few yards of the shore.

Length of third division, 21 miles 1,638 yards; total fall in the river, 340.325 feet.

In conclusion, it may be proper to remark that hereafter, on making a more minute and protracted examination of the ground preparatory to a permanent location, many alterations may be suggested in the position of the line of canal and its appurtenances. But it is believed that no material difference in the total expense of the work will result from such partial deviation.

All which is respectfully submitted.

R. A. HAZZARD,
Lieutenant, United States Army.

Number of levels.	Length of each level. Miles.	Yards.	Number of locks to the beginning of each level.	Number of aqueducts in each level.	Number of culverts in each level.	Walling. Length.	Height.	Nature of excavation. Soil.	Rocks.
						Feet.	Feet.		
1	0	1,466	....	......	1	....	......	Clay	Sandstone.
2	2	....	3	......	3	....	......	Sandy	
3	2	1,193	4	......	2	....	......	Clay and sand	
4	2	500	5	......	5	....	......	....	
5	1	1,500	6	......	2	....	......	Clay	
6	1	1,246	7	......	......	863	20	....	Limestone and conglomerate rock.
7	1	170	8	......	1	....	......	Alluvial	
8	1	1,350	9	1	1	255	23	Clay	Limestone. (A small aqueduct across Mill Creek, 100 feet in length and 17 feet high.)
9	0	763	10	......	......	....	......	Gravelly	
10	2	241	11	......	1	666	18.5	Stony	Sandstone.
11	1	340	12	......	1	228	10	....	
12	0	1,438	13	......	1	....	......	....	
13	0	1,233	14	......	......	....	......	Alluvial	
14	1	1,366	15	......	1	....	......	Clay	Valley of this small stream is 60 feet in width and 13 feet in depth.

Number of levels.	Length of each level.		Number of locks to the beginning of each level.	Number of aqueducts in each level.	Number of culverts in each level.	Walling.		Nature of excavation.	
	Miles.	Yards.				Length.	Height.	Soil.	Rocks.
						Feet.	Feet.		
15	0	1,295	16	1					Aqueduct across Muddy Creek, 50 feet in length and 19 feet above surface of the water.
16	1	853	17		5	756	17.5	Alluvial	
17	1	966	18		1			Clay	
18	1	49	19						Slatestone. Embankment 50 yards in length and 15 feet high.
19	2	1,251	20		3	810	22		Limestone.
20	1	104	21		1			Alluvial	
21	3	697	22			728	20	Gravelly	
22	2	524	23	1	1	408	25		Hard sandstone.
23	0	782	24			776	26		
24	0	497	25			491	25		
25	0	1,083	26			1,077	22		Hard sandstone.
26	1	507	27			1,286	20		
27	0	856	28			850	23		
28	1	671	29		2	833	25	Clay	
29	0	1,479	30					Gravelly	
30	0	556	31						
31	1	1,073	32		2			Clay	Rocky.
32	1	1,289	33		3				
33	0	1,156	34		2				
34	1	1,251	35		2				
35	1	1,596	36			1,266	23		Sandstone.
36	1	612	37					Sandy	
37	1	379	38		1				
38	0	677	39			528	13		
39	0	1,165	40		2				
40	1	642	41		3	500	21	Sandy	Sandstone.
41	0	896	42		1			Alluvial	
42	1	1,378	43		4			Sandy	
43	1	183	44						Sandstone.
44	0	1,234	45						
45	0	779	46			291	18		
46	1	347	47, 48			1,347	27		Compact sandstone. (Two contiguous locks are required at Richmond's Falls.)
47	1	1,127	49		1	390	17.5		Compact sandstone.
48	2	1,093	50		2	476	20	Clay	
49	0	1,433	51						Conglomerate rock.
50	0	839	52					Sand	
51	0	485	53		1				
52	1	473	54		2				Hill-slope, very steep and rocky.
53	1	940	55		2			Clay	
54	0	770	56		1				Sandstone.
55	0	1,613	57			925	17.5		
56	0	967	58					Sandy	
57	1	700	59						Stony.
58	0	1,663	60						
59	1	1,459	61		3	1,213	14		
60	0	1,600	62					Clay	
61	1	8	63						Rocky.
62	1	86	84			750	24		
63	0	1,400	65						
64	0	738	66	1					
65	0	628	67						
66	0	171	68						
67	0	171	69					Clay	Sandstone.
68	1	839	70			1,383	26		Red sandstone and limestone cliffs.
69	1	925	71					Sandy	
70	1	1,559	72		1			Sandy	
71	1	488	73			821	20		Sandstone cliffs.
72	1	1,474	74		1				Rocky.
73	0	767	75		1			Clay	
74	1	974	76		1				Along a very steep hill-slope.
75	0	637	77						
76	0	1,150	78						
77	0	1,300	79						Rocky.
78	1	1,021	80		2	475	25		
79	0	1,297	81		1				
80	0	800	82		1				
81	1	24	83						
82	0	843	84					Clay	
83	0	747	85						

From hence there are in all 42 levels and 46 locks to the surface of the water in the basin below the Great Falls; but the length of each level below Bowyer's Ferry, with such other details as are included in the tables, are reserved until the drawings shall be more advanced, on which every feature of the section will be fully exhibited. The precise termination of each level, with the most suitable position for the locks, involves considerations which are not at this time fully matured.

GEORGETOWN, D. C.,
Topographical Office, March 14, 1828.

To Capt. WM. G. MCNEILL:

SIR: I have the honor to submit the following table, exhibiting the discharge of the several streams which may be used for the supply of the proposed Roanoke and Kanawha Canal, from the mouth of Little River to the forks of the Roanoke, together with some few remarks upon those streams and the more important mineral localities observed in the vicinity:

Table of measurements.

Name of stream.	Date of measurement.		Quantity in cubic feet discharged per second.	Remarks.
	1827.			
South Fork of Elliot's Creek, at the forks	August	7	5.48	
Do		20	9.00	Slight fresh.
Do		22	5.08	
Do	October	12	5.45	
North Fork of Elliot's Creek, at the forks	August	7	3.80	
Do		20	8.00	Slight fresh.
Do		22	4.60	
Do	October	12	4.03	
Elliot's Creek, mouth		22	12.02	
South Fork of Roanoke, above Elliot's Creek		22	28.00	About the minimum.
Meadow Creek, near Hay's	September	21	6.44	About the minimum.
Little River, near the mouth of Meadow Creek		17	231.04	
Little River, 3 miles below Thompson's		6	161.70	Slight fresh.
Little River, at the commencement of feeder to the summit-level		19	118.00	
Do	October	4	97.00	
Do		14	111.05	

The number of mills upon these streams renders complete accuracy unattainable.

The measurements were made under the most favorable circumstances for learning the minimum supply of the streams; for not only the quantity of rain which fell during the season was unusually small, but the intervals of its falling were so great as to give us an opportunity of observing the strength of the springs.

Little River, I uniformly learned from those who resided on its banks, had never been lower than during this season, so that its minimum supply may, with common certainty, be assumed at what it is represented in the table.

In comparison with other streams in the vicinity affording the same quantity of water, Little River is very much the shortest, and by far the greater proportion of the supply is obtained from springs which have their rise within a few hundred yards of the river, a distance generally cleared along the whole of its length. No usual occurrence, therefore, can tend to lessen its supply materially; but should any circumstances whatever produce this effect, we may have resort to a reservoir, for which the valley of the river is well adapted; and a reservoir may also be formed in the valley of the South Fork of Elliot's Creek, near the fork, for a supply at that point.

The country is generally what is termed a limestone country, except about the upper part of Little River, where we have sandstone.

Compact limestone is the most abundant mineral production, but as to its presence united with the oxide of manganese, a union suitable for water-lime, I had not the means of ascertaining.

A fine locality of buhrstone was observed on the South Fork of Elliot's Creek, 12 miles from the Roanoke, containing a great proportion of silex, and very porous.

Iron ore was noticed on Little River, ferruginous red oxide of copper on Elliot's Creek, and galena or sulphuret of lead on New River.

I am, sir, very respectfully, your obedient servant,

JOHN M. FESSENDEN,
Second Lieutenant Fourth Artillery, on topographical duty.

TOPOGRAPHICAL OFFICE,
Georgetown, D. C., February, 1828.

To Capt. WILLIAM G. MCNEILL,
United States Topographical Engineer:

SIR: Agreeably to your instructions, I have the honor to report upon the duties assigned to me while employed upon the surveys and examinations relating to a proposed route for a canal between the headwaters of the Kanawha and James Rivers, in the State of Virginia.

During the months of August and September, 1826, and the months of May and June, 1827, I ascertained, by frequent measurements of the streams on each side of the dividing-ridge, the quantity of water to be relied upon for the supply of the summit-level, together with the portions of canal between the extremities of the summit-level and Jackson's and Greenbrier Rivers.

In the mean time I also made an examination as to the supply of water for a canal to connect the headwaters of Craig's Creek, a tributary to Jackson's River, with Sinking Creek, a branch of the Kanawha.

During the latter part of the season of 1827 I reconnoitered the country in the vicinity of Huntersville, Pocahontas County, to ascertain whether or not a connection could be formed there between Jackson's and Greenbrier Rivers.

While in the performance of these duties, agreeably to instructions received from you, I made frequent observations relative to the formation of the country which I traversed. I shall give the result of my observations in the order in which they were made; showing, in the first place, that there is a sufficient supply of water for a canal on the route from the mouth of Dunlap's Creek, at Covington, to the mouth of Howard's Creek.

The following tables contain the quantity of water discharged by the several streams to be relied upon for the supply of a canal on the different routes examined:

TABLE I.—*Exhibiting the quantity of water obtained by the measurement of streams on the proposed route for the James River and Kanawha Canal, in Virginia, during the months of August and September*, 1826.

Name of stream measured.	When measured.		Where measured.	Quantity of water per second in cub. feet.
Jackson River	Aug.	7	At Pitcher's mill, near Covington	130.5
Do		7	Above the mouth of Dunlap's Creek	157.9
Do		24	Above Pitcher's mill	152.65
Do	Sept.	6	Above the mouth of Potts's Creek	156.8
Do		4	Below the mouth of Dunlap's Creek	246.3
Dunlap's Creek	Aug.	7	Below the mouth of Augley's Creek	92.6
Do		7	At its mouth	25.6
Do		9	Above the mouth of Snake Run	19.83
Do		16	At its mouth	9.43
Do		17	.....do	10.26
Do		24	.....do	24.0
Do	Sept	27	.....do	22.0
Snake Run	Aug.	9	.....do	5.5
Augley's Creek		7	.....do	1.12
Potts's Creek		7	.....do	65.3
Do		16	.....do	34.9
Do	Sept.	4	.....do	38.6
Craig's Creek	Aug.	25	Below the mouth of Roaring Run	157.7
Do	Sept.	1	Below the mouth of John's Creek	38.3
John's Creek		1	At its mouth	15.4
Do		1	.....do	16.3
Do		1	.....do	15.85
Sinking Creek		1	Below Johnson's mill	0.49
Do		1	At Johnson's mill, when there is a maximum head of water at the mill	6.40
Greenbrier River	Aug.	10	Above the mouth of Howard's Creek	238.7
Do		20	.... do	134.7
Do		20	At Bright's mill	68.44
Do		21	One mile above Bright's	70.00
Do		25	Above Howard's Creek	148.6
Do	Sept.	5	Below Howard's Creek	97.0
Do		6	Six miles below Anthony's Creek	66.72
Do		7	At Bowen's mill	46.7
Do		7	Below Bowen's mill	128.0
Do		7	Above McClure's mill	73.3
Do		7	At McClure's mill	67.6
Do		8	Above Laurel Run	68.0
Do		8	Above Stamping Creek	42.3
Do		25	Below Howard's Creek	142.6
Howard's Creek	Aug.	10	Below the White Sulphur Springs	11.6
Do		19	.....do	7.8

TABLE I.—*Exhibiting the quantity of water obtained, &c.*

Name of stream measured.	When measured.		Where measured.	Quantity of water per second in cub. feet.
Howard's Creek	Aug.	25	At its mouth	6.83
Do	Sept.	5	......do	12.9
Do		5	......do	10.9
Anthony's Creek		6	......do	14.3
Do	Aug.	21	Six miles above its mouth	11.5
Spring Creek	Sept.	7	Near its junction with Greenbrier River	9.6
Locust Creek		8	Near its mouth	0.66
Do		8	At a mill near its mouth	0.704
Stamping Creek		9	Near its mouth	5.00
Beaver Creek		9	......do	2.5
Knapp's Creek		14	Six miles above its mouth	41.0
Second Creek	Aug.	29	Below Patton's mill	33.3
Do		29	At Knox's Ford	28.29
Do		29	Near the Gap Mill	30.09

TABLE II.—*Showing the quantity of water found in the streams on the proposed route for the James River and Kanawha Canal, in Virginia, during the months of May and June, 1827.*

Name of stream measured.	When measured.		Where measured.	Quantity of water per second in cub. feet.
Jackson's River	May	4	Below the mouth of Dunlap's Creek	350.00
Do		18	.....do	568.78
Do		19	.....do	607.00
Do		25	.....do	1,800.00
Do	June	5	.....do	600.00
Do		16	.....do	419.70
Greenbrier River	May	9	Below mouth of Howard's Creek	1,768.00
Do		10	.....do	1,995.00
Do		16	.....do	1,970.60
Do		12	.....do	4,000.00
Do		22	.....do	6,650.00
Do		24	.....do	2,000 00
Do		25	.....do	1,500.00
Do		27	At Bowen's mill	1,224.00
Do		27	At McClure's mill	882 00
Do	June	5	At the bridge	1,800.00
Do		26	Near McClure's	752.30
Augley's (or Ogley's) Creek	May	1	At Callaghan's mill	10.80
Do	June	16	At its mouth	9.50
Do	May	21	.....do	50.00
Do	June	26	.....do	60.00
Howard's Creek	May	16	.....do	40.40
Do		21	.....do	370.00
Do		24	Below Dickson's Run	49.30
Do		24	Near its mouth	184.60
Do		25	.....do	180.00
Do	June	6	.....do	360.00
Do		7	Near Little Dickson's	67.60
South Fork of Howard's Creek	May	16	Near the toll-gate	5.57
Do		22	.....do	80.00
Do		24	.....do	30.00
Do		25	.....do	26.00
Do	June	19	.....do	27.00
Dunlap's Creek	May	17	Above Colonel Crow's	41.50
Do		17	Below Crow's mill	52.90
Do		19	At its mouth	79.30
Do		21	Below Squire Bishop's	323.02
Do	June	5	Below Augley's Creek	50.00
Do		16	.....do	19.80
Potts's Creek	May	19	At its mouth	85.10
Mill Creek		23	.....do	142.72
Dickson's Run		24	Near its junction with Howard's Creek	31.00
Spring Creek		27	At Burr's mill	56.00
Locust Creek		27	Near its junction with Greenbrier River	84.00
Anthony's Creek	June	27	One mile below Wiley's, and near the intersection of the *feeder-line, &c.*	433.10

NOTE.—All the streams mentioned in the foregoing tables were measured by means of a float, with the exception of Dunlap's Creek, which, on the 10th and 17th days of August, was measured by means of a waste-wier or dam. At mills, the method prescribed for measuring by means of orifices has generally been adopted.

The quantity of water given in the fourth columns of the tables is expressed *in cubic feet per second.*

TABLE III.—*Of the quantity of water found in the streams on a proposed route for the James River and Kanawha Canal, in the vicinity of Huntersville, in the county of Pocahontas, Virginia, (May and June, 1827.)*

Name of stream measured.	When measured	Where measured.	Discharge of water in cubic feet.
Greenbrier River	May 29	Below the mouth of Knapp's Creek	2,400
Do	June 2	Seven miles above the mouth of Deer Creek	420
Do	10	Ten miles below mouth of Knapp's Creek	432
West Fork Greenbrier River	25	At its junction with East Fork Greenbrier River	777
East Fork Greenbrier River	25	At its junction with West Fork Greenbrier River	220
Knapp's Creek	May 29	Near Huntersville	156.9
Do	31	Above the mouth of Sugar-Tree Creek	15.0
Do	June 10	....do	78
Warm Spring Run	May 30	Four miles below Warm Springs	28
Do	June 9	....do	14
Jackson's River	May 30	Midway between the Warm Springs and the mouth of Little Back Creek.	448
Do	June 9	....do	140
Big Back Creek	May 30	Above the mouth of Little Back Creek	296
Do	June 10	.... do	140
Little Back Creek	May 31	At its mouth	50.6
Do	June 10	... do	20
Sugar-Tree Creek	May 31	Near its mouth	15
Sitlington's Creek	31	Near where a feeder-line would strike it, &c	100
Deer Creek	June 1	Above Woodle's mill	86
Do	19	... do	50
Camp Run, a branch of Deer Creek.	1	At its mouth	11
Duncan's Run, a branch of Deer Creek.	1	.....do	10
Buffalo Run, a branch of Deer Creek.	1	.....do	10
Salisbury Run, a branch of Deer Creek.	1	.....do	11
Back Creek	24	Near McCloud's	200
Knapp's Creek	19	Above the mouth of Sugar-Tree Creek	10
Six other small runs	19	Where a feeder would strike them, &c	16.00

I will now point out the resources which may be relied upon to supply with water the summit-level and the portions of canal on the Covington route between the mouth of Dunlap's Creek and Howard's Creek. It is known from the surveys which have been made on this route that we must, in a measure, depend for a supply of water upon the following streams, viz:

	Cub. ft.
Greenbrier River, (minimum supply,) 8th September, 1826	42.3
Greenbrier River, (mean supply,) 1826	67.6
Anthony's Creek, 6th September, 1826	11.6
Dunlap's Creek, 9th September, 1826	5.5

Besides the supply from these streams, we can avail ourselves of a reservoir, which shall contain either 13,060,584.9 cubic yards or 4,603,040 cubic yards, according to the height of the dam which may be constructed at the point where the feeder from Greenbrier River is taken. To show that this supply will suffice to feed the summit-level, to supply its lockage, and feed, besides, the portion of the canal contiguous to it, we have made the same suppositions with regard to this route that the board for internal improvement did with regard to the proposed route for the Chesapeake and Ohio Canal. Suppose, in the first place, the navigation to be interrupted four months in the year, viz. from the 1st of December to the 1st of April. Adopting 67.6 cubic feet per second as the mean supply of water afforded by Greenbrier River first, in the winter season, at the point where the feeder to the summit commences in said stream, it will be found that the larger reservoir would be filled twice during the interruption of the navigation, and the lesser reservoir would be filled in nearly one-third of the time required to fill the larger one. But 67.6 cubic feet per second is certainly much less than the mean supply afforded by the Greenbrier River in the winter season. (See Tables II and III.) It is, in fact, thought to be much less than the mean supply during the season of open navigation.

So that, while the navigation continues open, upon this last supposition the larger reservoir would be filled at least every two months, and the smaller reservoir oftener than once per month from Greenbrier River itself. Now, in order that we may see what influence evaporation, &c., may have upon this supply, let us make a computation as to the supply which may be expected from rains.

This, it will be seen, besides making up for evaporation and soakages in the reservoir,

and in the feeder to the summit-level, will leave a very large supply which may go toward the feeding of the summit and portions of the canal contiguous to it.

We shall take an area of 55 square miles, which we suppose to supply Greenbrier River with rain-water. This area is chosen from an inspection of the map of this part of the country, from which we find that the sum of the lengths of the streams tributary to Greenbrier River exceeds 110 miles; and, from a knowledge of the country, we know the width of their valleys to average more than half a mile.

We shall assume for the fall of rain on this surface the least quantity which fell from the year 1817 to 1824, in the vicinity of Baltimore.

The least quantity fell in 1822, which was in the fall and winter, 16.7 inches, and for the six other months, 12.5 inches; making, for the whole year, 29.2 inches. So it will be found that the assumed area will receive during—

	Cubic yards.
The fall and winter	78,880,384
The spring and summer	59,117,696
The whole year round	137,998,080

From which it will be seen that the first quantity would be six times as much as would be necessary to fill the larger reservoir in the winter season; and seventeen times as much as would fill the smaller one; and that the second quantity would fill the larger reservoir more than four times in the summer, and the lesser one nearly thirteen times. Now, what is the evaporation, soakage, &c., compared with these quantities? Suppose the evaporation to be 32 inches per annum, which are equivalent on a surface equal to 1 square yard to 0.910 cubic yard. We will apply this to the feeder and reservoir. The feeder, which is about 33⅝ miles in length, will have a surface, say, equal to about 590,880 square yards; and, consequently, the evaporation on it would be equal to 541,300.8 cubic yards. Suppose now the soakage to be equal to one and a half times the evaporation, (which is, no doubt, considering the nature of the soil over which the feeder-line passes, a sufficient allowance.) This last supposition gives for the evaporation and soakage together, of the feeder, 1,353,252 cubic yards. The evaporation of the reservoir, taking the larger one, whose surface would be equal to 2,508,333.3 square yards, would be equal to 2,282,583,303 cubic yards; or the evaporation and soakage together equal to 5,706,458.25 cubic yards; making, for both the feeder and reservoir, the evaporation and soakage together equal to 6,059,710.25 cubic yards. Should we double the allowance above made for evaporation, &c., it would be seen that it could not even then be compared with the quantity available from rains. It is, in fact, very trifling, even when compared with the fall of rain during the spring and summer months. It should also be recollected that we have assumed for the fall of rain the least quantity which fell in the course of a number of years in a section of the country where the fall is not to be compared with that in the elevated section of country which we have examined.

I think, therefore, that it would be safe to adopt the following as the minimum supply of water which can ever be expected on the route in question, and which will suffice to feed the summit-level and portions of canal contiguous to it, viz:

	Cubic feet per second.
Greenbrier River	42.3
Anthony's Creek	5.5
Dunlap's Creek	5.5

and the supply of 13,060,584.9 cubic yards from the reservoir, (using the larger one.)

It will be observed by reference to Table I that the least quantity of water found in Anthony's Creek, 6 miles from its mouth and near where the feeder-line strikes it, is 11.6 cubic feet per second; we have assumed less than half of it for the minimum supply. A less quantity is also assumed for Dunlap's Creek than has ever yet been found in it at any one point; one of its tributaries, Snake Run, gave, on the 9th of August, 1826, the same quantity which it will be perceived is assumed for the stream itself. And it should be recollected that the canal-line strikes the creek some distance below the mouth of Snake Run.

We could no doubt avail ourselves of several times the quantities assumed as the discharge of these streams; for, besides the actual quantities flowing in them, we can, if necessary, have recourse to small reservoirs on both of them; and, as regards Greenbrier River, it presents frequent sites for dams suitable for the formation of reservoirs; and that, should it be found necessary, one may, of almost any height, be formed at any point above the one chosen for the commencement of the feeder to the summit-level.

If necessary, reservoirs might be formed upon several of the tributary streams of Greenbrier River, and sometimes upon streams tributary to them.

But to limit the supply to the quantity above assumed, and calculating upon an open navigation of eight months in the year, it will be found that the monthly supply (adopting the larger reservoir) will be as follows, viz: 1,632,573.1 cubic yards from the

reservoir, 4,156,790.4 cubic yards from the Greenbrier River, and 1,055,980.8 cubic yards from Dunlap's and Anthony's Creeks, making the whole supply equal to 6,845,344.3 cubic yards.

This monthly supply may be disposed of after the following manner: Considering the length of the summit-level, it is probable that about two hours would be required for a boat to pass from one extreme point of it to the other—that is to say, it would move at the rate of a little more than one mile and a half per hour. This would be for a single boat. But, with a view to the saving both time and water, we will suppose the trade to be carried on by a number of boats, passing and repassing the different locks at the same time. Let the number be twenty. But, as a greater length of time is required for a number or train of boats to pass the summit-level than for a single one, we shall increase the time assumed for the passage of a single one one-half for a train—that is, we suppose it to take three hours for a train of 20 boats to pass from one end of the summit-level to the other.

The trade from the East to the West, we suppose, would be carried on in this manner. The first train of twenty boats would leave the first lock at the commencement of the summit-level, and arrive in three hours afterward at the lock at the other extremity of the level, (which we shall here call the second lock,) when it would meet a second train, having passed the second lock. This second train would arrive in three hours afterward at the first lock and find a third train, having passed during the passage of the first and second trains, and ready to proceed toward the second lock, and which would arrive there in three hours afterward, and find a fourth train having ascended to the summit and ready to proceed to the first lock; and so on, until the whole five trains shall have passed the summit.

The passage of these five trains, or one hundred boats, requiring fifteen hours, may be assumed as the greatest trade on this part of the canal.

It is readily seen that this trade agrees very well with the monthly supply, for, at the rate of 100 boats per day, 3,000 might pass per month, and 24,000 during the season of open navigation; and as the boats are supposed to pass the locks alternately, one lock full of water only for each boat will be required to pass the summit level. But to remove all doubts as to the adequacy of the monthly supply, we shall add half a lock-full for leakage, &c. This allowance, supposing the size of the locks the same as those contemplated by the board of internal improvements for the proposed Chesapeake and Ohio Canal, will be equal to 623 cubic yards; so that all the boats which would pass during a month would require for lockage 1,869,000 cubic yards of water, which, when taken from the monthly supply, leaves 4,976,344.3 cubic yards. This residue would supply the canal from the mouth of Howard's Creek to the mouth of Dunlap's Creek, a distance of about 33 miles 737 yards, at the rate of 148,992.34 cubic yards per mile per month, or 93,120.2 cubic feet per minute, which are equal to 1,552 cubic feet per second per mile.

And for the supply of the whole distance from the mouth of Howard's Creek to the mouth of Dunlap's Creek, we should have considerably more than 1¼ cubic feet per second per mile, should we take into consideration the quantity which may be had from Howard's Creek, some distance above its mouth. We speak now of 1¼ cubic feet of water per second, exclusive of lockage, and, if you please, of evaporation, soakage, &c. It is thought, however, to be a sufficiency, absorption, evaporation, &c., included. We might assure ourselves of this fact immediately by making a comparison between this supply and the different supplies which answer for many of the canals constructed in France and elsewhere. But I shall merely advert to the fact that, from experiments which have been made upon the New York canal and others which have been constructed in this country, it has been ascertained that about 100 cubic feet of water per minute per mile only are requisite for navigating an ordinary canal in this country, lockage included.

Now, if we apply this to the James River and Kanawha Canal, on a distance of about 33 miles 737 yards, and deduct 1,869,000 cubic yards, which we have allowed for lockage, we shall find that there will be a much smaller quantity left (and which would supply the canal) than we can calculate upon from Greenbrier River, Anthony's and Dunlap's Creeks, and the reservoir which would be formed on the Greenbrier. The foregoing calculations were made from data obtained from the experimental surveys made in 1826. Subsequent examinations develop facts which effect a slight change in them. By the recent surveys which have been made it appears that the feeder-line from Greenbrier River to the summit-level, can be shortened about 2 miles, making the entire length of it only 31 miles 130 yards.

The length of the summit-level is 4 miles 789 yards, and this distance from its eastern extremity to the point where the canal is fed by Dunlap's Creek is 2 miles 1,718 yards. The distance from thence to the mouth of the creek, 16 miles 115 yards. The distance from the point where the feeder-line strikes the summit-level to the point where the canal is fed by Howard's Creek is 3 miles 1,175 yards, and from thence to the mouth of the creek, 4 miles 740 yards, making the length of the canal, from the mouth of Howard's Creek to the mouth of Dunlap's Creek, about 31 miles 1,017 yards.

An alteration has been made in the situation of the dam for the reservoir on Greenbrier River. This dam, though supposed to be as high as the dam of the larger reservoir first calculated upon, is found to give a reservoir with a prism of water equal to only 8,578,148 cubic yards, but which, when compared with the former larger reservoir, is found to have a much smaller than a proportional surface exposed to evaporation.

The surface of this reservoir is equal to 532,666 square yards, and the evaporation from it would be equal to 484,726.06 cubic yards. If to this quantity, after making a due allowance for soakage, we add the evaporation and soakage of the feeder-line, and subtract the sum thereof from the quantity of water available from rains, the residue would still be more than sufficient to fill the adopted reservoir once per month. Besides, it is probable that the reservoir would be filled once per month the year round from Greenbrier River. The quantity (67.6 cubic feet) first assumed as the mean supply of the river would fill it once in less than every forty days. So, to feed the summit-level and portions of the canal between its extremities and Dunlap's and Howard's Creeks, we may, with safety, calculate upon the contents of a reservoir formed in Greenbrier River, and the least quantities of water afforded by Greenbrier River, Anthony's Creek, Howard's and Dunlap's Creeks.

The supply would be as follows: Calculating upon an open navigation of eight months in the year, the reservoir formed in Greenbrier River would give a monthly supply of 1,072,268.5 cubic yards. And from Greenbrier River, containing 42.3 cubic feet per second; Anthony's Creek, 5.5 cubic feet per second; Howard's Creek, 6.8 cubic feet per second; and Dunlap's Creek, 5.5 cubic feet per second, we should have a monthly supply of 5,769,552.6 cubic yards. If from these supplies we subtract the lockage for 3,000 boats per month, it will be seen that the residue would feed the entire canal from the mouth of Howard's Creek to the mouth of Dunlap's Creek at the rate of something like 157,517 cubic yards per mile per month, which are, exclusive of lockage, more than sufficient for that purpose, all other losses included.

The canal may be fed in this manner: From Greenbrier River the reservoir formed in it, and Anthony's Creek, affording together a monthly supply of 5,661,068.5 cubic yards per mile. From this quantity there will be left, after feeding the summit-level and the portion of canal between its eastern extremity and the mouth of Dunlap's Creek, (a distance of about 23¼ miles,) about 618,519 cubic yards per month, that is, after deducting lockage for both extremities of the summit-level and taking into consideration a monthly supply of about 528,000 cubic yards afforded by Dunlap's Creek more than 16 miles from its mouth. Now, this remaining supply of 618,519 cubic yards per mile, &c., together with a supply of 652,800 cubic yards per mile per month from Howard's Creek, more than 4 miles from its mouth, will feed the remaining portion of the canal from the western extremity of the summit-level to the mouth of Howard's Creek, a distance of about 8 miles.

If we found the calculations upon the least quantities of water which have yet been found to flow in the streams used on this route, at the points where it is probable they would be brought into requisition to feed the canal, it will be seen that the fall of rain-water need not be so much relied upon. For instance, we have Greenbrier River, containing 46.72 cubic feet per second, (see Tab. 1;) Anthony's Creek, 11.50 cubic feet per second; Howard's Creek, 6.83 cubic feet per second; and Dunlap's Creek, 9.43 cubic feet per second; giving altogether a monthly supply of 7,150,030 cubic yards. If to this supply we add the monthly supply from the reservoir, which we supposed filled from Greenbrier River during the interruption of the navigation, and make a deduction for lockage, there will remain a monthly supply of 6,353,348.5 cubic yards, which would supply the canal under consideration at the rate of 194,581.2 cubic yards per mile per month, which are, at least, more than half a cubic foot per second per mile more than is necessary for that purpose; and which, together with a small quantity of rain-water, would supply the losses of the feeder, &c.

Before concluding, we will make one other supposition. Suppose an open navigation of nine months in the year; and suppose the feeder from Greenbrier River to the summit-level, and the canal from the mouth of Howard's Creek to the mouth of Dunlap's Creek, to lose each its prism of water per month by evaporation and filtration, and allow 1,454,178.18 cubic yards for the leakage and evaporation of the reservoir, (supposing the former to be twice the latter,) and making a due allowance for lockage, we shall have, during an open navigation of nine months, all losses equal to about 32,962,494.18 cubic yards. Now, if we compare this with the fall of rain even during the spring and summer, there will remain a monthly supply of 2,906,133.53 cubic yards of water, which may go toward supplying the canal. That is to say, we should have for the supply of the canal, including running water, a monthly supply of 8,771,933.53 cubic yards, after having made good all losses; which is twice as much as is necessary. I shall finish these remarks by repeating, that, when we take into consideration the many favorable sites for dams, suitable for the formation of reservoirs on Greenbrier River and elsewhere, we can never dread an insufficiency of water for the supply of a canal on this route. In addition to this fact, the relative situation of Cheat River with regard to Greenbrier River, by which, in case of any unexpected casualty, a feeder, with a suf-

ficient supply of water for a canal, might be brought from thence to the Greenbrier River, leaves no doubt of the practicability of a canal communication between the head-waters of James River and the Kanawha.

The next object which occupied my attention was the examination of a proposed route for the James and Kanawha Canal, by way of one of the head branches of Craig's Creek, a tributary to Jackson's River, and Sinking Creek, a tributary to the Kanawha. I deem it unnecessary to enter into a minute description of the country along this route, as I shall be able to show in a very few words that there is not a sufficient supply of water for a canal. To supply the summit-level of a canal on this route we should have to rely almost altogether on John's Creek, a branch of Craig's Creek, which gave on the 1st September, 1826, at its month, a discharge of water equal to only 15.4 cubic feet per second, which is not perhaps the minimum supply during the driest season of the year. As regards Sinking Creek, we might often during the dry season expect to find it, if not dry, almost so. Relying then principally on John's Creek, we should have a monthly supply of water which would not suffice for lockage alone. Allowing the same quantity of water for lockage on this route as we did on the Covington route, we would want an additional quantity of 391,560 cubic yards per month for lockage. (Referred to on p. 777.)

The quantity of water afforded by John's Creek, (15.4 cubic feet per second,) and the quantity afforded by Sinking Creek, (.49 cubic feet,) together equal to 15.89 cubic feet per second, would have to supply a summit-level and portions of canal, together equal to, at least, from 30 to 36 miles. Now, at the rate of 1¼ cubic feet per second, it is readily seen that the above quantity would only feed a canal something like 10 miles, exclusive of lockage.

In a word, the great additional supply of water wanted for a canal by this route can never be had, for we can alone expect it from reservoirs, and though one or two might be formed on the route they could be but small.

A canal by this route, even if there was a sufficient supply of water, would have nothing to recommend it, for we would certainly have a very long tunnel on it, and that, too, over an elevated summit-level.

The foregoing remarks would apply equally as well to any route by the way of Potts's Creek, &c.

The next examination which I made, agreeably to the instructions received from you, was of the country between the head branches of Jackson's River and Greenbrier River, in the vicinity of Huntersville in Pocahontas County.

My attention was particularly directed to the ascertaining of the fact "whether or not the Greenbrier River, near the mouth of Knapp's Creek, approached sufficiently near to Jackson's River or some of its branches; and whether or not the dividing ridge between those streams was sufficiently depressed to admit of a connection between them by means of a canal without a tunnel."

There are, it is true, several depressions in the Alleghany Mountains, or dividing ridge between the eastern and western waters, in the county of Pocahontas. There is one 7 or 8 miles from Huntersville, between the head-waters of Knapp's Creek and Little Back Creek; and another still higher up, between the head-waters of the Sugar Tree Creek, a branch of Knapp's Creek, and Big Back Creek, a branch of Jackson's River.

But the most considerable one in the mountain is where the road from Huntersville to Warm Springs, in Bath County, crosses it; a communication might be made between Knapp's Creek and Back Creek through this gap perhaps without a tunnel, or, if with one, a very short one. But for a sufficient supply of water for a canal between those streams, we should have to resort to a long feeder from Greenbrier River, and one, too, perhaps, with one or two tunnels.

Table III shows the quantity of water afforded by the different streams in this section of the country at the time I made the examination of it. But we could not depend on anything like those quantities during the greater portion of the summer season.

From a mere examination of the table it will be seen that at the time the different streams were measured there was a supply of water afforded by them more than necessary to effect the desired communication. But having since seen many of these streams whilst employed upon the examination of a route for the Baltimore and Ohio Railroad, (during the dry season,) I am fearful there could not be had at all seasons of the year a sufficient supply of water for a canal communication by this route. But even if there could be found a sufficient supply, it would not then compare with the route from Covington to the mouth of Howard's Creek, as will be plainly seen from the following facts: On this route the length of canal would be greater, by at least 100 miles, than by the Covington route; that is to say, the distance (following the probable direction for the location of a canal) from the Greenbrier Bridge to Huntersville, on Knapp's Creek, and from thence over the dividing ridge, and down Back Creek, &c., to Covington would be at least 100 miles, and probably more.

The fall of the ground from the western extremity of the summit-level of this route to the Greenbrier Bridge, near the mouth of Howard's Creek, is about 1,500 feet. So

to make a comparison between the lockage on this route and that on the Covington route, we have the amount of lockage from the western extremity of the summit-level on the Covington route to the mouth of Howard's Creek equal to 224 feet, and the amount of lockage from the eastern extremity of said summit-level to the mouth of Dunlap's Creek equal to 694 feet, making the amount of lockage for the entire distance from the mouth of Howard's Creek to the mouth of Dunlap's Creek equal to 918 feet; consequently the fall from the eastern extremity of Pocahontas summit to the mouth of Dunlap's Creek is equal to 1,970 feet, making 2,552 feet more of lockage on the Pocahontas route than on the Covington route.

The great additional number of aqueducts which would be required on this route would make the cost of its construction very great when compared with the Covington route. In the distance from the mouth of Howard's Creek to the mouth of Knapp's Creek, pursuing either side of Greenbrier River, it would be found necessary to cross from 8 to 10 of the tributary streams of the Greenbrier; and, owing to the frequent situations in the Greenbrier River itself, it is probable that it would be found necessary to cross it four or five times in some instances to save distance, and in others to avoid encountering bad ground, &c. The same remarks would apply to Jackson's River. So, without a tunnel and with a sufficient supply of water, I am of opinion that the Pocahontas route could have no advantages over the Covington route.

I will now conclude by making some general remarks as to the formation of the country which we have examined for the purpose of ascertaining the practicability of a connection between Greenbrier and Jackson's Rivers. The rocks in the vicinity of the dividing ridge between these streams are of the transition class, and consist principally of sandstone and limestone. Hornstone and other rocks are sometimes met with, but in very small quantities. Of the rocks above mentioned, sandstone is perhaps the most predominant. Compact limestone, (blue,) however, occur in considerable quantities throughout the whole district, and may be used either as a building-stone or for the purpose of furnishing ordinary lime The most considerable deposit of limestone which we have seen in this section is a zone or belt which passes from north to south through Lewisburg, Union, &c., and which we have traced from its outgoings or appearances on the surface of the earth for the distance of 20 to 30 miles; its width hardly ever exceeds a mile. Connected with this deposit of limestone for a number of miles is one of hornstone.

Limestone is found on most of the streams east and west of the dividing ridge, viz, on Jackson's River, on Craig's Creek, on Dunlap's Creek, and on Angley's Creek. In a word, the whole country, from Covington to the Sweet Springs, abounds in limestone. It is found on Sinking Creek, on Knapp's Creek; on Anthony's Creek we generally find sandstone. On Greenbrier River, above the bridge, we sometimes meet with limestone, but the usual formation is of sandstone.

And it may here be remarked that the feeder-line from Greenbrier River to the summit-level will seldom intersect limestone formations, although we frequently find limestone in the vicinity of the Greenbrier, on either side, as high up as Huntersville, in Pocahontas.

Freestone, suitable for constructions, is found on both sides of Greenbrier River, near the bridge; of this stone, the piers of the bridge are constructed.

I examined the country, particularly between Howard's Creek and Crow's, on Dunlap's Creek, in the direction of the proposed tunnel between those streams, and came to the conclusion that, in the construction of the tunnel for the principal part of the way through the ridge, solid sandstone would be met with.

And whenever this was not the case, which would probably be in the commencement and termination of the tunnel, we should probably encounter argillaceous slate and sandstone with a slaty structure.

The soil throughout the whole section of country examined is generally very good, but varies in quality in a measure with the different kinds of rock met with, limestone soil being better than sandy soil.

Coal and iron ores are the only mineral productions discovered worthy of much notice.

Coal has been discovered some few miles from the bridge on Greenbrier River and will probably be found elsewhere, as we have frequently observed formations with which it is almost always associated. We have noticed the appearance of it particularly between the Greenbrier Bridge and Lewisburg. We have not, however, seen any specimens of a good quality.

This section of country is, unquestionably, the repository of numerous beds or deposits of iron ore. We are assured of this fact by its appearance in several places. A considerable lead of it is found on John's Creek, near New Castle. It also abounds on Dunlap's Creek and its branches, in the neighborhood of Covington, and will, no doubt, be frequently met with elsewhere.

The ore on Dunlap's Creek is the red oxide and is considered of a most excellent quality.

All of which I have the honor respectfully to submit, &c.

JOHN N. DILLAHUNTY,
Lieutenant First Regiment Artillery, on Topographical Duty.

REPORTS ON IMPROVEMENT OF THE GREAT KANAWHA RIVER BY LOCKS AND DAMS, BY MR JOHN A. BYERS.

1.

WINGFIELD, *February* 1, 1868.

DEAR SIR: I have sent to your address an estimate of the cost of improving the Kanawha River by locks and dams from Loup Creek to the Ohio River.

I have also sent an estimate for an improvement by locks and dams from Loup Creek to Brownstown and from thence down by low dams at the head of the shoals, side-canals along at locks at the foot of the shoals, each of these plans to secure 5 feet depth of water for navigation.

In planning any system of works for the improvement of a water-course, regard should be had to the height and character of its floods, and the materials composing the banks and bed of its stream.

Passing by occasional floods of from 50 to 60 feet as beyond any practical consideration, the Kanawha River is generally visited by one to several tides of from 20 to 30 feet every year.

These floods sometimes occur when New River for 150 miles, Greenbrier for 60 miles, Gauley River for about the same distance, are in many parts covered with strong ice, these rivers having an average fall of 10 feet to the mile. New River, taking its rise in the warmer climate of North Carolina, is sometimes flooded by rains falling there, while it remains dry and cold west of the Alleghanies. The effect under these circumstances is to drive the ice along, accumulating as it goes, until it is thrown down upon the Kanawha River in a compact mass, and rolled along the bottom of the river, forming dams from shoal to shoal, the destructive power of which should not be overlooked. Immense quantities of drift often carried with the flood even trees of the largest size. with the roots attached and dragging on the bed of the river.

The banks of the Kanawha River range from 40 to 60 feet above low water, and are made up of clay, sand, and vegetable mold mixed in every proportion. The river-bed is nearly everywhere covered with a close and strong pavement of bowlders filled in between with small stones and gravel.

Passing below this rocky pavement, which is from 3 to 5 feet in thickness, are found alternating strata of gravel and sand, of pure sand, blue clay, and quicksand, reaching generally far below the levels required for foundations.

Solid rock is exposed at Johnson's and Red House Shoals at a few feet above low water, extending only across a portion of the river, where it sinks abruptly to a level inaccessible for building upon.

I found solid rock at Peeled Maple and Arbuckle Shoals along both shores of the river, at a very uniform depth of 4½ feet below the surface of low water, and I believe solid rock will be found in other places along the shallow reaches of the river.

Considering the character of the river as above described, I have estimated for building entirely on artificial foundations. The walls of the locks, dams, and abutments are to be of masonry laid in hydraulic cement, the materials and workmanship to be the best of its kind, with no expenditure merely for the sake of appearance, and the prices applied, except for mortared masonry, are prices now paid for similar work in progress on Coal River.

In the estimate you will notice what may be considered a large sum for coffer-dams, &c., but, considering all the difficulties to be encountered, I cannot believe the charge materially in excess.

Coffer-dams will be necessary to the proper execution of the works, and they should be carried 4 to 6 feet above the ordinary low water, so as to render all the building-season for founding the locks and dams available by being above the ordinary summer floods.

It must be thought of, that, while these locks and dams are in progress, the navigation of the river will be often obstructed and occasionally suspended. To economize these difficulties the work will have to be pressed, so as to shorten the obstruction to navigation, by working night and day, all tending to increase the cost of the work.

ESTIMATE SHOWING THE COST OF IMPROVING THE KANAWHA RIVER FROM LOUP CREEK TO THE OHIO RIVER.

By mortared-masonry locks and dams.

12 locks, at $68,077	$816,924
12 dams, at $74,179	890,148
Channels of approach to the locks	100,000
Coffer-dams, pumping, &c	60,000
	1,867,072

By mortared-masonry locks and dams from Loup Creek to Brownstown, and side-canals and locks below.

5 locks, at $68,077	$340,385
5 dams, at $74,179	370,895
Channels of approach to locks	51,500
13 locks at foot of the shoals, at $60,600	787,800
13 dams at head of the shoals, at $14,000	182,000
Side canals	226,000
Coffer-dams and pumping	90,000
	2,048,580

By mortared-masonry and timber crib-dams, locks throughout.

12 locks, at $68,077	$816,924
12 dams, at $43,135	517,620
Channels of approach to locks	100,000
Coffer-dams and pumping	60,000
	1,494,544

By timber cribs, locks, and dams.

12 locks, at $54,805	$657,660
12 dams, at $43,135	517,620
Channels of approach to locks	100,000
Coffer-dams and pumping	60,000
	1,335,280

I have endeavored, in the foregoing estimates, to arrive at an aggregate of cost that will not vary materially from the truth. There is yet to be added a sum for the purchase of land for abutments and lock-houses, say $3,000, and also for administrative expense, which will be common to any plan that may be adopted.

I feel a great diffidence in recommending any particular plan for the improvement of the Kanawha River, while those most interested express such opposite views, but after giving the subject my best consideration I would respectfully suggest that a charter be obtained giving a right of choice to improve the river, in whole or in part, by locks and dams or by sluices, with the privilege of increasing the number of dams as the interest of the company may demand, and I would recommend the construction of locks and dams at Lykens's Shoals, at Paint Creek and Cabin Creek Shoals, and perhaps, also, at Witcher's Creek. The other points of the river are to be improved by collecting the water at the head of the shoals into a lateral canal or sluice alongside the shoal, and wing-dams, or submerged dams of riprap and gravel below the shoals, so placed as to grade the low-water surface to a descent nowhere more than three feet to the mile. These dams will sometimes extend from one shore and sometimes from the other, and sometimes extend entirely across the river, with a notch through for the boats the size of the channel. In short, they will be arranged in every manner to suit local requirements. When the river is graded with channels of the present width (80 feet on the bottom) and the water collected in the channel, there will be 4 feet depth of water when the river is at low-water mark, or 4 inches above what it was in 1838, when gauged by E. H. Gill, esq.; but the fact is within my observation of Kanawha River that it does not often fall within eight to ten inches of 1838, and instead of 4 feet there will be, with few exceptions of short duration, from 4 to 4½ feet and upwards.

It will, however, most likely be necessary to widen the channel to 100 feet on the bottom for the more safe and convenient passage of steam-tugs with a tow on each side. This will reduce the low-water depth to about 3 feet 3 inches.

The channels and various dams should confine the entire discharge of the river to a depth of 6 feet before the walls become submerged. If this is attended to, it will at once be seen that a general rise of less than 2 feet in the river will give 6 feet depth for navigation.

I would remark here that the bed of the river must be graded to a fall of 3 feet per mile, as well as the surface.

The following is an estimate of the cost of improving the Kanawha River as above proposed:

ESTIMATE FOR TIMBER-CRIB, LOCKS AND DAMS.

For dams and locks at Lykens, Paint, and Cabin Creek Shoals	$293,820
For the construction of channels, wing and submerged dams, &c	450,000
	743,820

I do not wish to be understood that the foregoing estimates are more than a close, but full approximation to the cost, according to the several plans given. The fall, width, and character of the river are taken from carefully-prepared notes of the survey made in 1856–'57–'58. The cost of a lock or dam has been prepared from pen-sketches in sections and plans, and the prices applied for all but masonry-work are those now being paid on the Coal River works.

Respectfully submitted.

JOHN A. BYERS.

THOS. L. BROUN.

2.

WINGFIELD, *February* 10, 1868.

DEAR SIR: I have thought it best to send you the estimates I have prepared, showing the cost of improving the Kanawha River by locks and dams and otherwise.

I have not said anything in regard to the Meadow River Lake, preferring to make that a separate report to Colonel Broun or yourself, so that it may be used or not; but I will state briefly here some of the advantages of such an aid to the improvement not only of the Kanawha but of the Ohio River.

By the water held back in the lake a navigable depth of the channel of the Kanawha can be maintained at 4 feet, for sixty days, during low water, and add 6 inches to the depth in the Ohio channels to Cincinnati. In addition to this, it will afford water to fill the bed of the Kanawha for 88 miles to a depth of 6 feet in the channels six times during low water, or once every two weeks for three months, and to fill the Ohio River below Point Pleasant the same depth for 54 miles; or, if applied uniformly, would raise the water in the Kanawha River to 4½ feet for sixty days. And this without grading of the river, by simply cutting channels at the shoals and removing surface or loose rock and gravel bars in other places.

The cost for such an improvement would be, taking Mr. Ellet's estimate for the river, as follows:

8,500 acres of land, at $7	$59,500
1,800 acres of land, at $20	36,000
500 acres of land, at $50	25,000
Cost of removing turnpike	5,000
Contingencies	25,700
	154,200
Cost of dam	215,500
Cost of improving the Kanawha by channels, &c	450,000
	819 700

The $450,000 for the improvement of the Kanawha includes the grading to 3 feet to the mile not contemplated by Mr. Ellet, and will probably add 6 inches or more to the depth of water.

Mr. Ellet put the channeling of the Kanawha at $125,000, which leaves $325,000 of my estimate to perfecting the improvement of the natural low-water discharge of the river.

I will, however, send a revised statement of this in a day or two.

One use of the reservoir would be to prevent the freezing over of the river by flooding during cold weather.

Very respectfully,

JOHN A. BYERS.

Col. THOMAS SMITH.

ESTIMATED COST OF A LOCK OF 7 FEET LIFT, 200 FEET LONG BY 40 FEET IN THE CHAMBER.

3 000 cubic yards excavating earth and gravel above low water, at 40 cents	$1,200
5,000 cubic yards excavating earth and gravel below low water, at 75 cents	3,750
500 cubic yards excavating solid rock below low water, at $2	1,000
7,300 linear feet of floor-timber, at 30 cents	2,190
70,000 feet, board-measure, of following-plank and pile-plank, at $40 per M	2,800
3,200 cubic yards of mortared masonry, (laid in cement,) at $7	22,400
1 100 cubic yards of dry masonry, at $3	3,300
3,000 cubic yards of embankment, at 25 cents	750
1,600 cubic yards of puddling, (not paid for as excavation,) at 50 cents	800
11,200 bushels of cement, at 50 cents	5,600
20,000 linear feet round piles in foundation, at 33⅓ cents	6,667

3,000 linear feet square timber in foundation, at 30 cents	$900
1,200 cubic yards of rock and gravel filling in foundation, at 60 cents	720
Miter-sills	400
Lock gates and fixtures	5,000
Lock-keeper's house	600
Coffer dams and building	10,000
Total cost of lock	68,077

ESTIMATED COST OF A DAM 600 FEET LONG.

5,000 cubic yards of excavation of earth, gravel, loose rock, &c., at 75 cents	$3,750
22,000 linear feet of round piles under the dam and apron, at 33⅓ cents	7,333
32,000 linear feet of square timber in foundation, at 30 cents	9,750
66,000 feet, board-measure, of plank, in foundation, at $35 per M	2,310
3,100 cubic yards of stone filling in grillage, at $1	3,100
28,800 pounds iron bolts in grillage, at 10 cents	2,880
3,300 linear feet of square timber covering the dam, at 50 cents	1,650
23,800 feet, board-measure, of plank flooring of dam, at $40 per M	952
16,000 pounds of screw-bolts and spikes in flooring of dam, at 15 cents	2,400
2,730 cubic yards of mortared masonry, (laid in cement,) at $5	13,650
1,200 cubic yards of mortared masonry in abutment, at $4	4,800
2,500 cubic yards riprapping, at $1	2,500
13,800 bushels of cement, at 50 cents	6,900
3,000 cubic yards of stone and gravel filling against the dam, at 40 cents	1,200
1,000 cubic yards rock filled over the gravel, at $1	1,000
Coffer-dams, pumping, and bailing	10,000
Total cost	74,175

MATERIALS AND LABOR FOR A DAM 600 FEET LONG, AND CONNECTED WITH A LOCK OF 7 FEET LIFT.

5,000 cubic yards of excavation of earth, gravel, and loose rock.
2_,000 linear feet of piles under dam and apron.
32,500 linear feet square timber in grillage and apron.
66,000 feet, board-measure, of plank floor and sheet-piling.
3,100 cubic yards of stone filling under floor and apron.
28,000 pounds of iron bolts in foundation.
3,300 linear feet square timber covering the dam.
23,800 feet, board-measure, plank and ice-guard covering the dam.
16,000 pounds of iron screw-bolt anchors and spikes to secure top of dam.
2,730 cubic yards of mortared masonry in dam.
1,200 cubic yards of mortared masonry in abutment.
2,500 cubic yards riprap protection of banks.
3,000 cubic yards stone and gravel filled against dam.
1,000 cubic yards rock on gravel filled against dam.
13,800 bushels of cement.
Coffer-dams, pumping, and bailing, $10,000.

MATERIALS FOR A MASONRY-LOCK OF 7 FEET LIFT.

3,000 cubic yards of excavation of earth above water.
5,000 cubic yards of excavation of earth under water.
500 cubic yards of excavation of rock, (mostly loose.)
7,300 linear feet of floor-timbers.
70,000 feet, board-measure, of planks, flooring, and piling.
3,200 cubic yards of mortared masonry.
1,100 cubic yards of dry walling.
3,000 cubic yards of embankment.
1,600 cubic yards of puddling, (not paid for as excavation.)
20,000 linear feet of piling in foundation.
3,000 linear feet of square timber in grillage.
1,200 cubic yards of rock and gravel filling.
Lock-gates and miter-sills and fixtures.
Lock-house.
11,200 bushels of cement.
Coffer-dams, bailing, and pumping, $10,000.

ESTIMATES OF CHANNELS ABOVE AND BELOW THE LOCKS.

By locks and dams all the way.

80,000 cubic yards of earth, gravel, &c., at 50 cents	$40,000	
50,000 cubic yards of embankment, at 30 cents	15,000	
15,000 cubic yards of dry walling, at $3	45,000	
		$100,000
Estimated cost of dredging, pile-driving, and pumping-machinery for same		60,000
		160,000

Estimated cost of channels for locks and dams to Brownstown, and side locks and canal below.

Channel to lock:		
40,000 cubic yards of earth, gravel, &c., at 50 cents	$20,000	
35,000 cubic yards of embankment, at 30 cents	10,500	
7,000 cubic yards of dry walling, at $3	21,000	
		$51,500
Side canal:		
126,000 cubic yards of excavation of earth, &c., at 50 cents	$63,000	
84,000 cubic yards of embankment, at 30 cents	25,200	
92,000 cubic yards of riprapping and paving, at $1.50	138,000	
		226,200
		277,700
Estimated cost of dredging, pile-driving, and pumping-machinery		90,000

RECAPITULATION.

Improving locks and dams all the way.

12 locks each, at $68,077	$816,924	
12 dams each, at $74,179	890,148	
		$1,707,072
Channels leading to and from the locks		100,000
Dredging, pile-driving, and pumping-machinery		60,000
Total cost by locks and dams all the way		1,867,072

Improvement by locks and dams to Brownstown.

5 locks, of 7 feet lift each, at $68,077	$340,385	
5 dams each, at $74,179	370,895	
		$711,280
Channels leading to and from the locks		51,500
Side locks and canals from Brownstown to the Ohio River:		
13 locks of 3.53 feet lift each, at $60,600	$787,800	
13 dams each, at $14,000	182,000	
		969,800
Side canal		226,000
For dredging, pile-driving, and pumping-machinery		90,000
Total cost of locks, dams, and side canals		2,048,580

3.

DEAR SIR: I desire to add some further views in regard to improving the Kanawha River by channels and weirs, which may be useful with some who are doubtful or incredulous as to what may be effected by that method.

In improving the Kanawha River from Witcher's Creek down, I propose to construct a navigable channel 110 feet wide on the bottom with interior side-slopes of 3 to 1. These channels will be formed by cutting through the bar at the different shoals, clearing away loose rock and gravel along the shallows and ripples, and in places by constructing dams or weirs, for the purpose of distributing the fall of the river so as nowhere to exceed 3 feet fall per mile.

The dams or weirs will generally be placed at right angles with the channel or cur-

rent of the river; some will be continued entirely across the river, with an opening left corresponding with the cross-section of the channel; the bottom of these openings in the dams will also be graded to 3 feet fall per mile.

Some of the weirs will extend from one or both shores of the river; some will be partly and some wholly submerged, and generally they are to have such location, direction, and extent as will secure the greatest depth of water for a safe continuous navigation.

The Kanawha River needs no further improvement than the cutting of channels at the shoals below Witcher's Creek, where the river is 2 feet above ordinary low water at the head of Elk River Shoal, provided the channels have a direction parallel to the current, so that boats and floats will not be wrecked on the side-walls.

I propose to show what can be effected in further improvement of the river by the addition of side-walls and weirs, as above indicated, during the time it remains between low water and 2.07 above at the head of the Elk Shoal.

The term "ordinary low water" is meant to apply to that stage in the river which generally occurs once or more in each year, and excludes such an extreme year as 1838.

In the summer of 1838 the river was carefully gauged by E. H. Gills, esq., civil engineer, and found to afford 1,150 cubic feet of water per second.

It has not been as low since that time. I made a similar measurement in 1856, and found 1,350 cubic feet per second. It was again gauged by Col. Charles Ellet in 1859, when he found 1,950 cubic feet.

This last gauging was made at the very time when steamers ceased to run on account of low water.

I propose to adopt a mean of the first and last measurements as the least quantity of water to be considered in showing the probable depth which will be obtained after making the proposed improvement.

In a channel of the dimensions before given, having an inclination of 3 feet in a mile, 1,550 cubic feet will give a depth of 3.25 feet in the channels; 2,147 cubic feet will give a depth of 4 feet, requiring 7 inches rise in river; 3,035 cubic feet will give a depth of 5 feet, requiring 13 inches rise in river; 4,150 cubic feet will give a depth of 6 feet, requiring 18 inches rise in river.

Mr. Ellet, in his report to the James River and Kanawha Company, states that with channels freely cut at the shoals, without otherwise confining the water, if it be raised so as to give a rise of 2.07 in the river at the head of Elk Shoal, it will give 6 feet depth of water everywhere below to the Ohio River.

The above are approximate figures, but I think are not far from the truth.

The statement above given shows, by grading the river and confining the low-water channel to a width of 110 feet, what a small rise is required to afford the depth of water desired. To complete this work I have estimated $450,000, which includes the smaller shoals and shallows between Lyken's Shoals and Witcher's Creek Shoal.

It has occurred to me to make an estimate of the probable depth of water for different lengths of time in one year, and I have to say there will be 3 feet and upwards for 11 months; there will be 4 feet and upwards for 10 months; there will be 5 feet and upwards for 9 months; there will be 6 feet and upwards for 7 months; there will be 3 feet and under for 1 month.

If nothing more is done than to clear out the channels, there will be, perhaps, 3 to 4 months in each year during which there will be 3 feet and less in the channels.

The discharge of 1,838 or 1,150 cubic feet per second would reduce the depth in the channels I propose to 2 feet 6 inches.

In fixing the width of the channel at 110 feet, I believe there will be no difficulty with a tug passing either way with a tow on each side, as they can and do ascend the present channels, which are only 80 feet wide.

Very respectfully, your obedient servant,

JOHN A. BYERS.

THOS. L. BROUN, Esq.

P. S.—I omitted to say that the entire river is intended to be turned into or to pass through the channels and weirs up to 6 feet deep, and every rise of the river must first expend itself in deepening the navigable water before it spreads over the whole river-bed.

J. A. B.

LAWS OF VIRGINIA AND WEST VIRGINIA RELATING TO IMPROVEMENT OF THE GREAT KANAWHA RIVER.

CHAPTER 114.—AN ACT to enlarge the powers and define the duties of the Kanahawa board, and to authorize them to prosecute the improvement of the Kanawha River. Passed March 3, 1869.

Whereas the Virginia Canal Company has failed to comply with the provisions of its original charter granted by the State of Virginia on the twenty-ninth day of March,

eighteen hundred and sixty-one, and has also failed to comply with the provisions of an act of the general assembly of Virginia, passed February third, eighteen hundred and sixty-one, which was intended to re-enact and amend said charter, and which last-mentioned act was approved by this legislature on the twentieth day of February, eighteen hundred and sixty-six; this legislature, by virtue of the power reserved to it by the three before-recited acts, doth hereby announce and declare, that by reason of the failure aforesaid, all rights, interest, franchises of the said Virginia Canal Company, within the jurisdiction of this State, have forever ceased and determined as fully and effectually as if neither of the aforesaid acts had ever been passed; and whereas the general assembly of the State of Virginia, having by an act passed March twenty-third, eighteen hundred and sixty, entitled "An act to amend the charter of the James River and Kanawha Company," declared "that in case the said James River and Kanawha Company shall not complete the canal to Covington, or the western terminus of the Virginia Central Railroad, within six years from the passage of this act, all the property, rights, franchises, and privileges, of every kind and description, of the said company, shall be transferred to and become the property of the State;" and the said James River and Kanawha Company having accepted the provisions of said act, and having failed to complete the canal to Covington, or the western terminus of the Virginia Central Railroad within six years from the twenty-third of March, eighteen hundred and sixty, so much of the property, rights, franchises, and privileges of said company as are situated within the limits of this State became and were vested in the State of West Virginia, by the thirteenth section of the said act of March twenty-third, eighteen hundred and sixty, and by virtue of the act passed on the third day of February, eighteen hundred and sixty-three, by the general assembly of Virginia, which transfers to the State of West Virginia all the property which the State of Virginia owned within the limits of this State. The legislature doth therefore declare and announce that the Kanawha River, and all dredge and other boats and property under the control of the Kanawha board are now the property of this State, free from the claims, incumbrances, or control of any party, State, or corporation whatever: Therefore,

Be it enacted by the legislature of West Virginia:

1. The board of public works shall annually appoint five directors for the Kanawha board, with power to sue and be sued, as a body politic and corporate, who shall have control and supervision of the Kanawha River, according to the provisions of the act providing more effectual means for the improvement of the Kanawha River, passed February fifteenth, eighteen hundred and fifty-eight, and an act to amend the charter of the James River and Kanawha Company, passed March twenty-third, eighteen hundred and sixty, so far as the same may be consistent with the provisions of this act. The said board of directors shall hold their offices for one year and until their successors are appointed, and shall have all the powers pertaining to the said board as fully as if they had been appointed according to the provisions of the said act, passed February fifteenth, eighteen hundred and fifty-eight. The board of public works shall on the fifth day of March, in each year, or as soon thereafter as practicable, appoint two collectors and one superintendent, who shall hold their offices for the term of one year and until their successors are elected and qualified.

2. The Kanawha board is hereby authorized to borrow not exceeding two hundred thousand dollars for the purpose of improving the navigation of the Great Kanawha River, and paying the just debts contracted by said board on account of said river; and may issue bonds therefor with coupons attached, bearing any rate of interest not exceeding ten per cent. per annum, and as security for the payment of the same, may execute a lien or liens on the Kanawha River, the improvement thereof, the revenue arising therefrom, and on all the property now in possession of or under the control of said board. The said bonds shall be payable at not more than twenty years from their date, but the said board may reserve the right to redeem or pay the same at any time after five years from the date thereof, provided that in no event shall the State of West Virginia be liable for any of the debts or contracts of said Kanawha board.

3. It shall be the duty of the Kanawha board to prosecute the improvement of the Kanawha River either by contract or by agents of the board upon a plan and specifications to be recommended by a competent engineer and approved by the board, and the said board shall expend in such improvement the surplus tolls arising from the river, which may not be required to meet the present liabilities of the board, or to pay the interest on the bonds authorized to be issued by this act, and to provide a sinking-fund to pay such bonds at maturity.

4. The treasurer and collectors of tolls shall severally execute bonds with good security, and in an amount to be approved by the Kanawha board, for the faithful discharge of their respective duties, and the prompt accounting for and payment of all moneys that may come into their possession. The collectors shall render weekly accounts of the tolls collected by them, and shall pay to the treasurer at the end of each week the money that they may have received during the preceding week.

5. The officers and agents of the company may be allowed a reasonable compensation for their services, to be fixed by the Kanawha board, but the collectors of tolls shall be allowed a commission on the amount received and paid over by them, as a compensation for their services, to be fixed by the Kanawha board.

6. One of the collectors of tolls shall be stationed at Charleston and the other at Point Pleasant, and their collection-district shall be so arranged as to secure the collection of all the tolls.

7. The Kanawha board shall make semi-annual reports to the board of public works of all their transactions, and the amount of money received and the manner of expending the same, which report shall be published in a newspaper at the seat of government.

8. The Kanawha board may elect one of their number president, who shall perform such duties as may be assigned to him by the said board, for which he shall receive a reasonable compensation, to be fixed by said board. Each director shall be entitled to $3 for each day's attendance on the meetings of the board.

9. After the improvement of the river and the payment of the debts contracted therefor, the rate of tolls shall be reduced so as to yield only a sum sufficient to pay expenses and keep the works in repair.

10. The Kanawha board shall have power to collect tolls at not exceeding the following rates: For commodities transported on steamboats, flat-boats, barges, and all other description of water-craft, between Charleston and the mouth of the river, and in the same proportion for transportation for less distance; that is to say, on salt, 4 mills per bushel; on wheat, beans, pease, dried fruit, flax and other seeds, 1 cent per bushel; on corn, potatoes, apples, and corn-meal, 4 mills per bushel; on bacon, 3 cents per 100 pounds; on lard, butter, cheese, and tallow, 4 cents per 100 pounds; on sugar, 4 cents per 100 pounds; on coffee, 5 cents per 100 pounds; on cordage, 4 cents per 100 pounds; on nails, iron, and hemp, 3 cents per 100 pounds; on flour, 3 cents per barrel; on cider, vinegar, and pickles, 6 cents per barrel; on pork, beef, and molasses, 8 cents per barrel; on linseed, lard, and refined coal or petroleum oil, 10 cents per barrel; on crude petroleum, or coal oil, 8 cents per barrel; on whisky, rum, brandy, gin, and foreign wine, 1 cent per gallon; on native wine, 10 cents per barrel: on ale and beer, 5 cents per half-barrel, and in the same proportion for larger or smaller packages; on salt fish, 10 cents per barrel; on manufactured tobacco, 5 cents per 100 pounds; on leaf tobacco, 3 cents per 100 pounds; on live and slaughtered hogs, 5 cents each; on dry goods, 10 cents per 100 pounds; on pig-iron, 20 cents per ton; on empty barrels, 2 cents per 100; on hoop-poles for barrels, 3 cents per 1,000; on hogshead-poles, 10 cents per 1,000; on pipe-staves, 20 cents per 1,000: on all articles not enumerated, 4 cents per 100 pounds; on coal, at the rate of 1 mill per ton per mile; on steamboats carrying passengers, ½ cent per passenger per mile for each passenger carried; on lumber and timber, 75 cents per thousand feet, board-measure.

11. In the event that the board of public works should elect hereafter to proceed against the Virginia Canal Company or the James River and Kanawha Company by inquisition, inquest, or judicial proceeding, more formally to ascertain the termination of their franchises over the Kanawha River, authority is hereby vested in it to institute such proceedings in the name of this State; and full benefit of such procedure shall inure to the State of West Virginia and of the perfecting of its title to the Kanawha River.

12. All acts and parts of acts inconsistent with the provisions of this act are hereby repealed.

CHAPTER 115.—AN ACT to provide for the improvement of the Great Kanawha River. (Passed March 3, 1869.)

Whereas the Virginia Canal Company has failed to comply with the provisions of its original charter, granted by the State of Virginia on the 29th day of March, 1861, and has also failed to comply with the provisions of an act of the general assembly of Virginia, passed 3d of February, 1866, which was intended to re-enact and amend said charter, and which last-mentioned act was approved by this legislature on the 20th day of February, 1866; this legislature, by virtue of the power reserved to it by the three before-recited acts, doth hereby announce and declare that by reason of the failure aforesaid, all rights, interests, and franchises of the said Virginia Canal Company within the jurisdiction of this State have forever ceased and terminated as fully and effectually as if neither of the aforesaid acts had ever been passed; and whereas the general assembly of the State of Virginia, having by the thirteenth section of an act passed 23d March, 1860, entitled "An act to amend the charter of the James River and Kanawha Company," declared "that in case the said James River and Kanawha Company shall not complete the canal to Covington or the western terminus of the Virginia Central Railroad within six years from the passage of this act, all the property, rights, franchises, and privileges of every kind and description of the said company

shall be transferred to and become the property of the State." And the said James River and Kanawha Company having accepted the provisions of said act, and having failed to complete the canal to Covington or the western terminus of the Virginia Central Railroad within six years from the 23d March, 1860, so much of the property, rights, franchises, and privileges of said company as are situated within the limits of this State, became and were vested in the State of West Virginia, by virtue of the said thirteenth section of the act aforesaid, and by virtue of the act passed 3d of February, 1863, by the general assembly of Virginia, which transfers to the State of West Virginia all the property which the State of Virginia owned within the limits of this State. The legislature doth therefore declare and announce that the Kanawha River is now the property of this State, free from all claims, incumbrances, or control of any party, State, or corporation whatever: Therefore,

Be it enacted by the legislature of West Virginia:

1. That the governor of West Virginia, James H. Brown, and Charles W. Smith, of Kanawha County, Daniel H. K. Dix, of Putnam County, and John M. Phelps, of Mason County, are hereby appointed commissioners on the part of the State of West Virginia, whose duty it shall be to offer the benefits of this charter for the acceptance of capitalists, so as to secure the improvement of the navigation of the Great Kanawha River from its mouth to Loup Creek Shoal. To this end they, or a majority of them, are empowered to contract with any person or incorporated company who shall give the best terms, and the most satisfactory assurances of capacity and responsibility; and to introduce into said contract any additional stipulations for the benefit of the State and in furtherance of the purposes herein declared, and not inconsistent with this act; which said contract shall be, to all intents and purposes, as much a part of this charter as if the same had been herein included at the time of the passage of this act. The persons upon whom the benefits of this charter may hereafter be conferred, and who may be duly organized as a company, shall thereupon be constituted a corporation, under the name and style of the "Great Kanawha Improvement Company," and shall have all the powers, rights, and privileges conferred by code of West Virginia on similar corporations, subject, however, to the restrictions therein contained, so far as the same are applicable to, and not inconsistent with, the provisions of this act. The certificate of the commissioners of the due execution of the said contract, and the organization of the company, shall operate to confer on said company all the benefits of this charter: *Provided*, That no such contract or transfer of the river and other property of this State shall take effect until approved by the board of public works of this State: *Provided further*, That said commissioners shall not directly or indirectly receive any emolument from, or have any interest in, any company created by this act, except that they may each receive their necessary expenses incurred in the execution of the duty imposed upon them by this act from said company, when organized, and the State shall not be liable for any of the expenses of said commissioners.

2. The capital stock of said company shall not be less than five hundred thousand dollars, nor more than four million dollars, to be divided into shares of one hundred dollars each. And any railroad, mining, manufacturing, banking, or other incorporated company, may subscribe to the stock, and guarantee the bonds of the Great Kanawha Improvement Company.

3. When the company shall have been duly organized, it shall be the duty of said commissioners to certify the fact to the Kanawha board, and thereupon it shall be the duty of the Kanawha board to turn over to the said Great Kanawha Improvement Company the possession, use, and control of the Kanawha River, and the property hereinafter mentioned, to be held, used, and enjoyed, in pursuance of the provisions of this charter.

4. All dredge and other boats in the possession of the Kanawha board, and pertaining to the improvement of the river, with all other property of every kind thereto pertaining, shall belong to the said company when it takes control and possession of the river; but the said company shall pay off and discharge all the debts and liabilities incurred for the purchase of the same, including mortgage-bonds issued by the Kanawha board under the authority of the legislature.

5. The company shall place and keep good buoys and ring-bolts, wherever needed, for the guidance, safety, and convenience of navigators.

6. The company shall have power to appoint receivers of tolls at such points as it may designate.

7. When the company takes control and possession of the river, and shall have expended $100,000 in improving the same, it shall have power and authority to collect tolls at the following rates for commodities transported on steamboats, flat-boats, barges, and all other description of water-craft, between Charleston and the mouth of the river, and in the same proportion for transportation for less distances. That is to say: On salt, 4 mills per bushel; on wheat, beans, pease, dried fruit, flax and other seeds, 1 cent per bushel; on corn, potatoes, apples, and corn-meal, 4 mills per bushel; on bacon, 3 cents per 100 pounds; on lard, butter, cheese, and tallow, 4 cents per 100 pounds; on sugar, 4 cents per 100 pounds; on coffee, 5 cents per 100 pounds; on cordage, 4 cents per

100 pounds; on nails, iron, and hemp, 3 cents per 100 pounds; on flour, 3 cents per barrel; on cider, vinegar, and pickles, 6 cents per barrel; on pork, beef, and molasses, 8 cents per barrel; on linseed, lard, and refined coal or petroleum oil, 10 cents per barrel; on crude petroleum or coal oil, 8 cents per barrel; on whisky, rum, brandy, gin, and foreign wine, 1 cent per gallon; on native wine, 10 cents per barrel; on ale and beer, 5 cents per half-barrel, and in the same proportion for larger or smaller packages; on salt fish, 10 cents per barrel; on manufactured tobacco, 5 cents per 100 pounds; on leaf-tobacco, 3 cents per 100 pounds; on live and slaughtered hogs, 5 cents each; on dry goods, 10 cents per 100 pounds; on pig-iron, 20 cents per ton; on empty barrels, 2 cents per 100; on hoop-poles for barrels, 3 cents per 1,000; on hogshead-poles, 10 cents per 100; on pipe-staves, 20 cents per 1,000; on lumber, 75 cents per 1,000 feet, board measure; on all articles not enumerated, 4 cents per 100 pounds; on coal shall be charged tolls at the rate of 1¼ mill per ton per mile; and steamboats carrying passengers, ½ cent per passenger per mile for each passenger carried. And when the company shall have completed any section of ten miles or more of the improvement above Charleston, it may collect additional tolls thereon, and in proportion to the rates authorized to be collected below Charleston. And when completed, if the foregoing rates of toll shall not produce a net average annual revenue of 15 per cent. on the amount expended on the river by this company, then the company may increase *pro rata* the said tolls, so as to produce a net average annual revenue of 15 per cent.

8. When the company has completed the improvement of the river according to its charter, if at any time it is ascertained that its net annual revenue exceeds an average of 15 per cent. per annum, on the application of any toll-payer the judge of the circuit court of Kanawha County shall appoint three discreet disinterested freeholders residing within his circuit, who shall revise equitably the tariff of tolls herein provided, so as to produce, in their judgment, as near as may be, the net average annual income of 15 per cent. on the capital expended by this company. Said commissioners shall make their report to the said judge, who shall on hearing confirm the said report or recommit until said tariff is by him approved, which shall then be the tariff by which tolls shall be collected.

9. The navigation, improvements, and property of the company shall be exempt from taxation until the net income arising therefrom shall be 6 per cent. per annum.

10. Manifests (under oath, if required) of the cargoes of all boats navigating the Kanawha River shall be filed with the receiver of tolls, designating the names of the cargoes, of their owners, and the masters of the boats or other vessels in which said cargoes shall be shipped, and of the boats and vessels, together with those of the shippers or other agents having the control or direction of the said cargoes, and the legal tolls shall be demanded and paid to the collector of tolls accordingly. In all cases of failure to comply with the regulations hereby established and to pay the tolls aforesaid, it shall be the duty of the said receiver to seize and hold the boat or other vessel concerned in the neglect and evasion thereof until the law is fully complied with; and if that be not done within the space of ten days from the time of such seizure it shall be lawful for the receiver of tolls, after giving five days' previous notice of his intention, by advertisement at the door of the court-house of Kanawha County, to sell at public auction, for ready money, so much of the said cargoes of said boat or vessel as will be sufficient to pay the tolls due, with the addition of 50 per cent. thereon, and the necessary expenses incurred by the said receiver in seizing, securing, and taking care of the said vessel and cargo; and the said boat or vessel, with the remaining cargo and any balance of money which may remain from the sale aforesaid, shall be returned to the lawful owners or proprietors thereof, or to their agents. The said company, their receivers or agents, may sue out any attachment before any justice against boats and cargoes upon the Kanawha River, for tolls due and unpaid by the said boats, their owners, masters, or shippers, which attachment shall be prosecuted as in other cases of attachment for debt.

11. The receiver of tolls shall be authorized to board and enter boats or other vessels in the said river, whether in the stream or at anchor, or at the landing on either shore, or the Kanawha River, and to demand and receive the legal tolls on all commodities contained in said boats or vessels, whether fully or in part loaded, and in case of failure to pay the said tolls when thus demanded, the boats and vessels and the cargoes thereof shall be liable to seizure, sale, and disposition in all respects as prescribed in the foregoing section. And all and every person or persons on board of any boat or other vessels in the said river, and having control of the same, refusing or neglecting to come to, when required by the receiver to do so, shall forfeit and pay twenty dollars to the use of said company, to be recovered before any justice of the peace; and all persons resisting the said receiver in the execution of any powers given to him by law shall be deemed guilty of a misdemeanor, and be prosecuted accordingly.

12. All persons, whether principals or agents, who shall ship off, or authorize to be shipped off, any article subject to the payment of toll, without first having entered the same with the receiver of tolls, as herein prescribed, and having paid the tolls due

thereon, shall forfeit and pay three times the amount of the tolls on the articles so shipped off, to be recovered for the use of said company before any justice.

13. The receivers of tolls are hereby authorized to prosecute, in the name of the company, in the usual form, for any penalties, forfeitures, or punishments authorized and sanctioned by this act.

14. The company may proceed to condemn any lands which will be overflowed by reason of its improvements, and as many as five acres in one place, for erecting thereon locks, abutments, toll-houses, and other buildings necessary for navigation purposes, and may proceed to take from the adjacent lands any rock or earth necessary for its improvement. But before overflowing lands, or taking lands and materials, the said company shall proceed to ascertain the value of the lands to be overflowed, and of the lands and of the materials to be taken, in the methed provided in the Code of West Virginia, so far as the same is applicable to the circumstances, *mutatis mutandis*.

15. The company is required to commence *bona fide* the improvement of the Kanawha River within six months from the time it takes possession thereof, and to complete the improvement within five years thereafter. The upper part of the river, from Loup Creek Shoals down to such point as may be deemed necessary by the company, shall be improved by locks and dams. The residue of the river shall be improved upon such plan as may be recommended by engineers and adopted by the company. And if the plan of sluices should be adopted for any part of the river, the channel should be constructed of a proper width, grade, and depth, to be recommended by engineers and approved by the company and the said commissioners. And all the water flowing in the river shall be confined, as far as practicable, in the channels until they are full. The company shall expend not less than $1,000,000 in improving the navigation of the river within five years from the time it takes possession thereof, and shall expend not less than $200,000 during the first year thereof. In the event of failure to expend the specified amount, or to complete the improvements within the time required by the charter, the rights and franchises of the company shall cease and terminate.

16. The company may borrow money, and may issue bonds, with coupons attached, bearing any rate of interest not exceeding 8 per cent. per annum, and may sell said bonds at a discount, and as security for the payment of the same may execute a mortgage or deed of trust upon its corporate franchises and all its property, real, personal, and mixed.

17. The company is hereby authorized and empowered, if it shall so elect, to continue its water-line up the Kanawha Valley to New River, and thence up New River to the State line in the county of Mercer, and also up Greenbrier River to Howard's Creek, either by canal, sluices, locks and dams, or all or any combined. Should it elect to extend such improvement, it is hereby authorized to increase its capital stock not exceeding ten millions of dollars additional, and to borrow money, as before provided.

18. In the event that the said company should elect hereafter to proceed against the Virginia Canal Company or the James River and Kanawha Company by inquisition, inquest, or other judicial proceeding, more formally to ascertain the termination of their franchises over the Kanawha River, authority is hereby vested in it to institute such proceedings in the name of the State; and full benefit of such procedure shall inure to the said company, and of the perfecting of its title to the Kanawha River, at its own expense.

19. If hereafter, by authority of the legislature of Virginia and of West Virginia, any company shall be duly organized to construct a water-line from the Ohio River to the waters of Chesapeake Bay, that the company herein authorized may, with its consent, become a part of such enlarged organization, or may sell its works and franchises to such organization upon such terms as may be agreed upon. In no event, however, shall it prevent the establishment of such water-line, provided such through water-line company shall pay this company the fair cash value of the improvements made in money expended on the river under this charter and the future amendments thereof, which value shall be ascertained by arbitrators; and in estimating the value thereof no compensation shall be allowed for the franchises of the river or this charter, as the State hereby transfers said franchises to the Great Kanawha Improvement Company without compensation.

20. The company is hereby authorized and empowered to acquire land by purchase, in payment of stock, or otherwise, and to lease, sell, and dispose of the same at its pleasure.

21. Should the commissioners contract with any incorporated company to improve the navigation of the Great Kanawha River, such company shall have all the rights, interests, privileges, and franchises which by this act would be conferred upon the "Great Kanawha Improvement Company," if organized.

22. The governor is authorized to fill any vacancy that may occur in the board of commissioners.

23. When the Great Kanawha Improvement Company takes possession of the river in pursuance of this act, then all acts or parts of acts inconsistent with the provisions of this charter are repealed.

24. This charter shall remain and be in full force one hundred years from its date. But the right is hereby reserved to the legislature to alter or amend this act at its pleasure. And if the commissioners fail to make a contract, and the work be not commenced according to the provisions of this charter within two years from passage of this act, then, and in the event, this act shall terminate.

STATEMENT OF MR. C. HENDRICK, ATTORNEY FOR KANAWHA BOARD.

Before the year 1858 the Kanawha River was a part of the property of the James River and Kanawha Company, a corporation created by the laws of Virginia.

February 15, 1858, (Acts of 1857–'58, page 91,) it created the Kanawha board, consisting of five directors, and the president of the James River and Kanawha Company, who were interested, with the control, management, and supervision of the Kanawha improvement, subject to the instructions of the stockholders of the company. The improvement to be from the mouth of Loup Creek.

The above act was amended by an act on page 113 of Acts of Virginia of 1859–'60. The improvement of the Kanawha River to be under the exclusive control of the Kanawha board. To improve from mouth of Loup Creek. Registered stock of State to be issued. (See section 9.) Company to accept same before it goes into effect, &c.

Other acts were passed that need not be referred to here.

In the year 1869 the legislature of West Virginia passed an act (see Acts of West Virginia, 1869, page 75) which fixes definitely the status of the Kanawha River improvement. The preamble declares all rights, franchises, &c., of the old company forfeited to the State of West Virginia, so far as they are situated within the limits of the State.

Section 1 provides that the board of public works shall annually appoint five directors, with power to sue, &c., to have control and supervision of the river, and provide for its improvement, &c., according to the provision of act of February 15, 1858, and the act to amend, passed March 23, 1860.

Section 2 provides for borrowing money, issuing bonds, &c., not to exceed $200,000, to execute liens, &c.

Section 3 gives plan of improvement.

The Kanawha board have bonds outstanding, with coupons attached, (10 per cent.,) secured by mortgage on improvement, &c., amounting to about $17,000; probably $20,000.

The legislature of West Virginia, on the 21st of December, 1872, (Acts of 1872–'73, pages 751–752,) adopted a joint resolution, authorizing the board of public works to appoint nine (9) commissioners, to confer and negotiate with any commissioner or person who may be authorized to act on behalf of the United States in regard to the transfer of the rights, privileges, and franchises on said improvement, (three-fourths of them to act, &c.,) from the mouth of the Kanawha to mouth of Gauley, and over the New River from the mouth of Gauley to the mouth of Greenbrier, and over this from its mouth to the mouth of Howard's and Anthony's Creeks, &c.

The commissioners were appointed by the board of public works some time ago. I think Hon. A. T. Caperton, of Monroe County, and William A. Quarrier, of Kanawha, were two of them. The names of all may be obtained from the records of the board of public words.*

C. HEDRICK,
Attorney for Kanawha Board.

CHARLESTON, W. VA., *March* 15, 1875.

The property owned by the Kanawha board is worth $15,000 or $20,000.

C. H.

JOINT RESOLUTION providing for the transfer of certain rights and franchises of the State of West Virginia to the United States.

Whereas the Congress of the United States recently made an appropriation for a survey to ascertain whether it was practicable to construct a continuous water-line through this State to connect the waters of the Mississippi Valley with the Chesapeake Bay, and the engineers employed for that purpose have shown that such a line is practicable; and whereas the State of West Virginia regards the said line as a work of national importance, and is anxious to afford every facility for the construction of the same: Therefore, be it

Resolved by the Legislature of West Virginia:

1. That the State of West Virginia hereby agrees to transfer all the rights, privi-

*For names and address of commissioners, see end of joint resolution attached, of December, 1872.

leges, and franchises now owned or possessed by the State in the Kanawha River improvement, and the chutes, dams, wing-dams, channel, and all other work heretofore done in the Kanawha River, together with jurisdiction in and over the Kanawha River from its mouth to the mouth of Gauley River, and over the New River from the mouth of the Gauley to the mouth of Greenbrier River, and over the Greenbrier River from its mouth to the mouth of Howard and Anthony Creeks, and from the mouth of said creeks to the State line, and also the right, power, and franchise to construct, maintain, and operate a good and substantial through water-line from the mouth of the Kanawha River to the Chesapeake Bay, so far as the said water-line shall pass through and be located in this State: *Provided*, That the rights, privileges, and franchises herein mentioned shall never be so exercised as to affect or impair any right now vested in the Chesapeake and Ohio Railroad Company by or under the laws of this State.

2. The board of public works is hereby authorized to appoint nine commissioners on the part of the State, one to be chosen from each judicial circuit, any five or more of whom may act, to confer and negotiate with any commissioners or persons who may be authorized by law to act for and on behalf of the United States, in regard to a transfer to the United States of the said rights, privileges, and franchises. Three-fourths of the said commissioners, at least, shall consent to any contract or agreement that may be proposed touching the said transfer.

3. That the said commissioners shall, as soon as a contract is proposed to them, which they, or three-fourths of them, may deem acceptable and just, transmit it to the governor of this State, who shall submit the same to the legislature for their action, if it be in session at the time, and if the legislature be not then in session he shall convene it as speedily as possible for that purpose.

4. That the State of Virginia be respectfully requested to take concurrent action in the matter referred to in the foregoing resolutions, and that a copy of the same be sent by the governor of this State to the governor of Virginia, with the request that he lay them before the legislature of that State.

Adopted December 21, 1872.

In accordance with this joint resolution the board of public works appointed the following commissioners: A. J. Pannel, of Wheeling; James Morrow, Fairmount; W. H. Travers, Charlestown, Jefferson County; C. F. Scott, Parkersburg; J. M. Bennett, Weston; W. A. Quarrier, Charleston, Kanawha County; A. T. Caperton, Union, Monroe County; John Douglass, Princeton, Mercer County; and James D. Armstrong, of——.

The commissioners have never taken any action.

MARCH 15, 1875.

The board of public works consists of the governor, auditor, treasurer, superintendent of free schools, and attorney-general. (Acts of 1872-'73, page 71.)

AN ACT to amend and re-enact section one of chapter one hundred and thirty-two of the acts of 1872-'73, entitled "An act giving the consent of the legislature of the State of West Virginia to purchase, by the United States, of land within this State, for public purposes."

Be it enacted by the legislature of West Virginia, That section one of chapter one hundred and thirty-two of the acts of 1872-'73 be amended and re-enacted so as to read as follows:

1. That the consent of the legislature of West Virginia be, and the same is hereby, given to the purchase, heretofore or hereafter, by the Government of the United States, or under authority of the same, of any tract, piece, or parcel of land from any individual or individuals, bodies politic or corporate, within the boundaries or limits of the State, for the purpose of erecting thereon light-houses, beacons, works for improving navigation, post-offices, custom-houses, or any other needful public structures or works of improvement whatever; and all deeds, conveyances of title, papers for the same, shall be recorded, as in other cases, upon the land-record of the county in which the land so conveyed may lie, and in case such land cannot be acquired by purchase, the same may be acquired by said Government by condemnation, according to the laws of this State providing for the taking of lands without the owners' consent, for purposes of public utility: *Provided*, That the quantity of land shall not, at any one place, exceed twenty-five acres, and that the State of West Virginia hereby reserves the right to execute process, both civil and criminal, within the limits of any lot or parcel of land so purchased or acquired, as aforesaid, by the United States, the consent herein and hereby given being in accordance with the seventeenth clause of the eighth section of the first article of the Constitution of the United States, and with the acts of Congress in such cases made and provided.

Approved December 25, 1875.

AN ACT to aid in the improvement of the Fox and Wisconsin Rivers, in the State of Wisconsin.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That whenever, in the prosecution and maintenance of the improvement of the Wisconsin and Fox Rivers, in the State of Wisconsin, it becomes necessary or proper, in the judgment of the Secretary of War, to take possession of any lands, or the right of way over any lands, for canals and cut-offs, or to use any earth-quarries or other material lying adjacent or near to the line of said improvement, and needful for its prosecution or maintenance, the officers in charge of said works may, in the name of the United States, take possession of and use the same, after first having paid or secured to be paid the value thereof, which may have been ascertained in the mode provided by the laws of the State wherein such property lies. In case any lands or other property is now or shall be flowed or injured by means of any part of the works of said improvement heretofore or hereafter constructed for which compensation is now or shall become legally owing, and in the opinion of the officer in charge it is not prudent that the dam or dams be lowered, the amount of such compensation may be ascertained in like manner. The Department of Justice shall represent the interests of the United States in legal proceedings under this act, and for flowage-damages hereinbefore occasioned.

SEC. 2. That a portion of the appropriation now made for the further prosecution of the improvement aforesaid, not exceeding in amount twenty-five thousand dollars, may be applied in payment for the property and rights taken and used as aforesaid.

Approved March 3, 1875.

APPENDIX W.

REPORTS UPON BRIDGING NAVIGABLE WATERS OF THE UNITED STATES—PROTECTION OF PUBLIC WORKS FROM TRESPASS OR INJURY—INVESTIGATION OF ACCIDENTS ON RAILROADS.

W 1.

CONSTRUCTION OF RAILROAD BRIDGES ON THE MISSISSIPPI RIVER BETWEEN SAINT PAUL, MINNESOTA, AND SAINT LOUIS, MISSOURI.

ENGINEER OFFICE U. S. ARMY,
Newport, R. I., July 1, 1877.

GENERAL: I have the honor to submit the following report of progress in preparing the report on bridging the Mississippi River, between Saint Louis and Saint Paul, ordered by Congress in 1866.

This report has been so long in hand because of other more pressing duties, and there has been an almost continual increase of new and important data relating to the subject. Previous to the past fiscal year the surveys had not included the bridges and changes made since 1870, but in October and November last the additional surveys were made to bring the matter up to that time.

The maps have all been completed, and a copy filed at engineer headquarters in Washington. Another copy is also well advanced, prepared specially for publication by the photolithographic process.

All the material needed for the report has now been obtained, and the report is nearly finished, but it had to be put aside, temporarily, on account of the operations at this station. It is expected to complete the report in the autumn.

The information about existing bridges obtained by me, as far as it was needed, was laid before the Board upon sheer-booms, of which I was a member, last February; and tracings from the bridge maps were submitted with the report of the Board.

Very respectfully,

G. K. WARREN,
Major of Engineers and Bvt. Maj. Gen., U. S. A.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

W 2.

SHEER-BOOMS FOR BRIDGE-PIERS ON THE MISSISSIPPI RIVER.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., February 19, 1877.

SIR: To enable the honorable Secretary of War to comply with the requirements of "An act for the further security of navigation on the Mississippi River," approved March 3, 1875, I beg leave to submit the

inclosed copy of the Report of the Board of Engineers constituted to consider the subject of "causing sheer-booms to be placed on the upper end of all or any bridge-piers on the Mississippi River, for the better security and convenience of the navigation of said river for rafts of logs and timber, with specific report in each case," and to invite attention to the recommendations contained therein.

The report states clearly and concisely the difficulties experienced by rafts in passing the several bridges over the Mississippi River, and recommends the placing of sheer-booms at the following, viz:

Railway-bridge at Winona.
Railway-bridge at La Crosse.
Railway-bridge at Dubuque.
Railway-bridge at Clinton.
Rail and highway bridge at Rock Island.
Railway-bridge at Burlington.
Rail and highway bridge at Keokuk.
Railway-bridge at Quincy.
Rail and highway bridge at Hannibal.
Railway-bridge at Louisiana.

Floating structures are intended wherever booms are recommended, unless a fixed boom is specifically mentioned.

The Board gives generally the conditions which the sheer-booms should fulfill:

They should be stable enough to resist the shock of colliding rafts and vessels without overturning, and should have strength sufficient not to break under impact at any point. They should not have a less draught than 30 inches, and should project above the water-surface at least 6 feet, in order to prevent the guards of steamers from passing over them and breaking their wheels. The submerged faces of the booms on the sheering side should be smooth, and the faces above water should be so arranged as to allow vessels to rub against them without injury to themselves or the booms, and the booms should furthermore fulfill their duties at all stages of water. All pivot-pier guards should be planked longitudinally from 30 inches below low-water to 6 feet above high-water, and these guards should include the pivot-piers, so that no projection of the latter should be exposed beyond the face of the guards.

The Board, while confining its recommendations to aiding the passage of rafts, incidentally considered the passing of steamboats, being careful not "to recommend anything for the former that would be detrimental to the latter." In several cases it found the importance of further protection to steamboats more imperative than for rafts.

The Board states that it regards the booms and other constructions recommended "as but partial alleviations of the difficulties of raft-navigation, as the plans and locations of most of the bridges are such as to make any complete measure for the safety of navigation impossible."

The Rock Island bridge being owned and operated by the United States, a special appropriation by Congress of the sum of $15,000 will be required for the necessary protection at that point, the Board assuming that all the expenses attending the construction of booms, &c., at the other bridges that may be provided for by future legislation will be borne by the owners of the bridges.

The views and recommendations of the Board appear to me judicious, and are concurred in; and it is suggested that Congress be requested to provide such legislation as, in its judgment, may be necessary to carry them into execution.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brigadier General and Chief of Engineers.

Hon. J. D. CAMERON,
Secretary of War.

REPORT OF BOARD OF ENGINEERS.

SAINT LOUIS, MO., *January* 31, 1877.

GENERAL: The Board, constituted by Special Orders No. 52, Headquarters Corps of Engineers, June 22, 1876, to inquire into the expediency of causing sheer-booms to be placed above bridge piers on the Mississippi River, have the honor to present the following report:

The Board met at Saint Louis on the 17th of July, 1876, and proceeded to consider the letter of instructions from the Chief of Engineers and the act of Congress approved March 3, 1875, ordering the investigation. For convenience of reference, a copy of the act is here inserted:

AN ACT for the further security of navigation on the Mississippi River.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War be, and he is hereby, authorized and directed to inquire into the expediency of causing sheer-booms to be placed on the upper end of all or any bridge-piers on the Mississippi River, for the better security and convenience of the navigation of said river for rafts of logs and timber, with specific report in each case.

The act mentions no other floating structures than rafts of logs and timber, yet it calls for an inquiry into the expediency of placing sheer-booms above the piers of the bridges for their protection, &c., and further on a specific report in each case is required.

The two points in the act most noticeable appeared to be the word "expediency" and the clause "specific report in each case." The former seemed to the Board to involve consideration of not only the necessity of providing protection to rafts in passing the spans of the bridges, but also consideration of at least three other interests involved, viz:

1st. Interests of steamboat-owners which might be affected by the construction of such booms.

2d. The interest of bridge-proprietors, as the acts of Congress legalizing their bridges make it incumbent upon them to provide further securities for the safety of navigation whenever called upon to do so by the proper United States authority.

3d. Though of less importance, interests of riparian proprietors whose fronts might be obstructed by works put in for the protection of rafts.

The interests of this latter class being difficult of ascertainment, a precise statement of their nature could not be reached by the same process of investigation as the others named. Furthermore, such interests, being local in their nature, could not bear any comparison with the interests involved in the free navigation of a river like the Mississippi, bordered by numerous and populous States.

There being no definite information before the Board, the junior member, acting as recorder, was directed to obtain plans of all bridges contemplated in the order; an expression of the desires of the raft interests; objections, if any, of the steamboat interests, and statistics of the raft interests; pending the collection of which, the Board adjourned to reconvene at the call of the president.

Efforts were made accordingly to procure the requisite information, but not followed with the success desirable. Any officer of Engineers who has ever attempted to procure statistics of the business of our inland waters, where no systematic registration is kept or required, will readily appreciate the difficulty of the undertaking.

Letters were written to the officers of the companies owning or operating bridges crossing the Mississippi for maps and data; to the principal known lumbermen; to the officers of lumber companies in the valley

of the Upper Mississippi, and to the leading steamboat-men for statistics, general information, and suggestions; each formal letter of application containing either a condensed statement of the act of Congress under which the Board was acting or a copy of the act, in order that the importance of the information requested might be apparent.

The officers of the bridge companies courteously offered any data in their possession, but with the exception of some copies of bridge records pertaining to passage of rafts, boats, &c., and records of gauge-readings for a season or two, but little reliable information was obtained. In fact, some of the bridge companies had lost or mislaid all the original maps and records.

Replies from steamboat interests were meager.

From the raft interests fuller data were elicited than expected, and their statements, together with statistics of the trade, appear to be reliable.

The estimated total product of white pine of 1875 actually floated into the Mississippi River and marketed during that year was 1,069,000,000 feet, board-measure, including logs, lumber, shingles, &c. Estimated quantity which passed down the Mississippi River at the mouth of the Wisconsin River during 1875, in all forms, shingles, laths, logs, &c., 830,000,000 feet. About 550,000,000 feet pass the Dubuque bridge annually.. About 500,000,000 feet pass the Clinton bridge annually. About 400,000,000 feet pass the Rock Island bridge annually. Rafts vary in size from 300,000 to 2,000,000 feet. A fair average is 750,000 feet per raft.

The above figures are taken from a communication to the Board from Berthold & Jennings, lumber commission merchants of Saint Louis, who have made up the estimates partly from their own observation, but mainly from information obtained by them from the Treasury Department at Washington. Their communications in full are given in Appendix A.*

In a memorial to the Board, marked "B," in appendix, signed by the principal lumber-dealers of the Upper Mississippi Valley, the number of rafts annually run is stated at 1,100. This does not seem an overestimate, for the records of one bridge alone---that at Dubuque—show that 1,136 rafts passed under it during the navigation-season of 1875. It is possible, though, that at all the bridges the number reported may be slightly in excess, as large rafts are generally split up above them and the parts taken up again below, so that occasionally a raft may be counted twice.

The number of rafts passing each bridge is gradually reduced from the Wisconsin to Saint Louis, as comparison of the bridge-records with each other will show, and as might be expected; some of the lumber going to supply towns, while much of it is shipped by rail east and west from different points along the river. The raft-record begins at Dubuque, where, during the year 1875, 1,136 rafts passed the bridge, and ends at Louisiana, about 112 miles above Saint Louis, where for the same year 109 rafts are recorded as passing the bridge. Of the latter, a large portion reached Saint Louis, and a part also was landed at Alton for use and shipment at that point.

Before the construction of so many bridges across the river, rafting was generally done independently of steamboats; that is, the rafts drifted; but the difficulty attending the passage of bridges by rafts

* The appendixes to this report are omitted. They may be found printed in Ex. Doc. No. 41, H. R., 44th Cong., 2d Sess.

gradually led to the use of tow-boats, until now nearly all the rafts (as high a proportion as nineteen-twentieths has been stated) are towed.

The width of a raft is computed by the number of strings, a string being sixteen feet. All the spans of the bridges, raft-spans included, are too narrow for the free passage of the large rafts now constructed. Although a raft is said to be towed, it is in reality pushed, the position of the boat astern of the raft affording it better governing position.

The actual cost of rafting lumber from Stillwater to Saint Louis is stated by those familiar with the business at $2 per thousand feet, board-measure; very much less than the cost of transporting it on barges or by any other means. One large item of cost consists in detention in passing bridges which it is stated averages four hours per bridge per raft. In addition to this is the actual loss sustained by collision with the piers, a loss which it is difficult to estimate, though known to be great.

The principal steamboat-lines interested in the Mississippi River above Saint Louis are the Keokuk Northern Line, Capt. W. F. Davidson, president, and the Diamond Jo Line, Joseph Reynolds, president, besides numerous tow-boats. A statement of the business of the Diamond Jo Line, and a partial list of raft-boats, will be found in Appendixes C and D.

The impossibility of procuring suitable maps from the bridge companies early becoming apparent, application was made to the Engineer Department at Washington for maps, &c., on file there. In reply, information was given that General Warren was then engaged in making additional surveys, which it was expected would be completed in time for the use of the Board, and by letter of the Chief of Engineers, dated August 24, 1876, he was added to the Board as a member, and directed to notify the president thereof as soon as his maps were ready, and the Board directed to suspend proceedings until then.

The Board re-assembled in accordance with the following order:

UNITED STATES ENGINEER OFFICE,
Rock Island, Ill., January 16, 1877.

ORDERS: The Board of Engineers, constituted by Special Orders No. 52, Headquarters Corps of Engineers, 22d June, 1876, and letter of Chief of Engineers, dated 24th August, 1876, will meet at Saint Louis, Mo., on Friday, 26th January, 1877, or as soon thereafter as practicable, to continue the investigation as to the expediency of placing sheer-booms at the upper ends of bridge-piers in the Mississippi River, &c.

J. N. MACOMB,
Colonel of Engineers, U. S. Army, President of the Board.

General Warren laid before the Board a map (plan and profiles) of each of the bridges on the Mississippi River, showing the approaches both by land and water, the direction and velocity of currents, and depths of water for some distance above and below. The junior member also presented the information he had accumulated.

The Board then proceeded to hear the statements of the leading raft and lumber dealers, pilots, and steamboat-men. The statement of Messrs. Kempt, DacDonald & Kearns, given with the maps before them for reference, is appended and marked "E."

A model of the Pond sheer-boom was presented to the Board, and its merits explained by Messrs. Kempt & Chapman, representing the Eau Claire Lumber Company, which is part proprietor of the invention. Particulars of this boom will be found in Appendix F.

The Board then proceeded to the consideration of each bridge, beginning with the railway-bridge and the highway-bridge at Saint Paul. As but an insignificant quantity of lumber ever passes under these

bridges, it is not deemed necessary to place any booms there, and for the same reason no protection is deemed necessary above the bridge crossing the river at Hastings.

Before proceeding further, the Board here mention that inasmuch as the windings of the Mississippi River make the designation north or south, east or west, as applied to its banks, variable for each locality, the words right and left are used instead, the right bank being that on the right hand in descending.

RAILWAY-BRIDGE AT WINONA.

The first bridge crossing the Mississippi River below the Saint Croix River is known as the Winona bridge, which was built in 1871, and under act of Congress approved July 25, 1866. It consists in all of 16 spans of various lengths, two of them draw-openings, each 160 feet in the clear, and one a raft-span of about 240 feet in the clear; bottom chord at 10 feet above high-water; the range or difference between high and low water about 16 feet.

No record of rafts or steamboats passing bridge has been obtained, as none has been kept.

In running past this bridge rafts generally use the right draw-opening, the left draw-opening and long span adjoining being seldom accessible on account of the set of the current toward the right bank caused by a bar above. This action of the current renders it necessary to run direct for the draw-rest when making for the right draw-opening at time of high-water.

Additional difficulty arises from the location of Yeoman's boom, which obstructs the path of rafts following the set of the current, and from the Northwestern Railway Company's transfer-wharf, the front of which is piled, but not planked.

To aid in the security of raft-navigation at this bridge, a straight boom from the right rest-pier, extending up-stream to a point about 150 feet above the elevator, should be placed, and Yeoman's boom removed or drawn in toward the bank, so that no part of it should project more than 100 feet out from shore. The position of the proposed boom is shown on the accompanying tracing, numbered 1.*

RAILWAY-BRIDGE AT LA CROSSE.

The next bridge in order is that at La Crosse, built in 1876, under act of Congress approved April 1, 1872. This bridge has just been completed. It consists, in all, of ten spans of various lengths, having over the main channel two draw-spans, each 160 feet in the clear, and one raft span 240 feet in the clear; bottom chord 10 feet above high-water; range or difference between high and low water about 16 feet.

No records of rafts or steamers passing this bridge have been obtained.

The channel here has changed much during the past year. After the construction of the piers the right draw-opening, the only one accessible to rafts, was difficult to reach on account of the existence of a bar above the bridge and adjoining the island, and another bar working down from another island above and on the right of the channel. In order to reach this draw, rafts had to cross the stream at nearly a right angle, under the upper and above the lower bar. In addition, the velocity of current through the right draw opening is great.

Inasmuch as the right draw-opening will necessarily be the one used

* The maps herein alluded to are on file in the office of the Chief of Engineers, U. S. A.

by rafts, protection along the right bank for a distance of 1,000 feet above the abutment and similar to that designated for the Winona bridge should be placed. (See accompanying tracing, numbered 2.)

RAILWAY-BRIDGE AT PRAIRIE DU CHIEN.

The river here is separated by an island into two channels, both being navigable. That on the right is habitually used by rafts and raft-boats; that on the left is the main steamboat-channel, and is also used by such rafts as are destined to Prairie du Chien, numbering probably not more than ten or twelve in the course of a season. Both channels are crossed by a pile and ponton bridge; the ponton in each channel forming a draw of about 400 feet. The current is gentle in both channels.

This structure was legalized by act of Congress approved June 6, 1874.

The bridge is regarded by all interests concerned in the navigation of the river as the easiest one to pass, and no accidents of importance have been reported. The Board do not deem any booms necessary at this point.

RAILWAY-BRIDGE AT DUBUQUE.

This bridge was built in 1868, under act of Congress approved July 25, 1866. It consists in all of eight spans of various lengths and a trestle-approach some 2,400 feet in length, including two draw-openings, each 160 feet in the clear, and two raft-spans, each about 240 feet in the clear. The bottom chord of the bridge is at 10 feet above high-water; the range between high and low water is about 20 feet.

Eleven hundred and thirty-six rafts are reported as having passed this bridge during the rafting-season of 1875, of which 863 were towed. Thirty-three accidents to rafts in passing were recorded for this year. The details are contained in Appendix G.

The right draw-opening and adjoining long span are habitually used by rafts at all stages of water, the left draw-opening and adjoining span being seldom if ever used. During low water but little difficulty is experienced; at time of high water the current from Seventh-street slough, which discharges immediately above the bridge, creates cross currents, the effect of which cannot be anticipated.

A boom 1,200 feet long and on the prolongation of the axis of the right pier of the right raft-span, its upper end anchored, so that it can be swung, either to sheer rafts into the right raft-span or into the right draw-span, is required here. (See accompanying tracing, numbered 3.)

RAILWAY-BRIDGE AT CLINTON.

The portion of this bridge over the right-hand channel was commenced in 1864 and completed in 1865. That part over the left-hand channel was completed and in use some years previous. The structure was legalized as a post-road and post-route by act of Congress February, 1867.

The river here is divided into two channels by Little Rock Island. The bridge, spanning both channels, consists in all of fourteen spans, of different lengths. In right-hand channel there is but one draw-opening available, of 118 feet, and one raft-span of about 180 feet, clear width. Bottom chord about 6 feet above high water; difference between high and low water, about 20 feet.

At time of high water, most of the rafts run the channel to the left of the island, the only span available in which being the one next to the left bank. This span is obstructed by piles and riprap about the

piers, and its available width further reduced to about 180 feet by the obliquity of the axes of the piers to the direction of the current; and a further difficulty in this channel arises from a current setting across the bottom-lands.

During medium and low stages of water the right-hand channel is used. The draw and raft spans in this channel are all too narrow, being of less width even than those of any of the other bridges. Of these spans, the right-shore span and adjoining draw-opening are impassable for rafts on account of their being occupied by rafts of logs and timber, and also by boom-piers below. The only spans that can be used are the left draw-opening and the span adjoining, the approach to which is difficult on account of the eddy below the rocky point used as the steamboat landing of Clinton. For details of rafts and boats passing this bridge, see Appendix H.

A fender, 1,000 feet long, should be placed along the left bank of the left or east channel, above the bridge, in order to prevent rafts from being drawn into the bottom, and two booms should be placed in the right or west channel, one to extend from the upper end of the draw-rest and on its prolongation to the right bank, and the other to extend from the pier next to Little Rock Island up to the head of this island. (See accompanying tracing, numbered 4.)

RAIL AND HIGHWAY BRIDGE AT ROCK ISLAND.

This bridge was commenced in 1869 and completed in 1871, by the United States Government, under act of Congress approved July 25, 1866. It consists in all of seven spans, including draw, which has openings of 160 feet width, and two raft-spans with 250 feet width in the clear; bottom chord 10 feet above high water; range between high and low water is about 16 feet.

The number of rafts passing this bridge is as follows:

From March 29 to December 31, 1872	919
Year ending December 31, 1873	688
Year ending December 31, 1874	583
Year ending December 31, 1875	618
Year ending December 31, 1876	627

Details are given in Appendix I.

During high water rafts generally run the right span, next to the Davenport shore; at medium and low stages of the river they use both draw-openings and the span adjoining the right draw-opening.

The main difficulty experienced by raftsmen here arises from the bridge being located at the foot of the rapids, on which there is no point for some distance above the bridge where rafts can be split up, necessitating, in time of wind, the making of two trips over this distance. The roughness of the bank of the island immediately above the bridge renders the use of the south or left draw-opening dangerous.

The rocky bank of the island for 500 feet above the south abutment should be timbered and planked, and a boom similar to that designated for the bridge at Dubuque should be placed in the thread of the current, above and on the prolongation of the right pier of the left raft-span, and the remains of the north or right pier of the old bridge should be fully removed. (See accompanying tracing, numbered 5.)

RAILWAY-BRIDGE AT BURLINGTON.

This bridge was commenced in 1867 and completed in 1868, under act of Congress approved July 25, 1866. It consists, in all, of ten spans of different lengths, with two draw-openings, each 160 feet in the clear;

bottom chord 10 feet above high water; range of river, or difference between high and low water, 20 feet.

For particular description of this bridge, see letter of Mr. Hjortsberg, chief engineer Chicago, Burlington and Quincy Railroad, marked J, in appendix.

Rafts passing this bridge usually run the right draw-opening and adjoining span; this latter span being but 190 feet in width. The spans to the left of the draw are wider, but are only made use of when rafts are blown over from the right, or west, bank. Running the right span and draw-opening is rendered difficult on account of the existence of a hard bar of gravel near Berry's mill, which, with the eddy below it, produces a cross-current in these spans.

A boom 900 feet long should be extended up stream from the right rest-pier. (See accompanying tracing, numbered 6.)

RAIL AND HIGHWAY BRIDGE AT KEOKUK.

This bridge was commenced in 1869 and completed in 1870, under act of Congress approved July 25, 1866. It consists of 12 spans of different lengths. Two of them are draw-openings, about 160 feet each in the clear, and two raft-spans of about 240 feet. Bottom chord of the bridge 10 feet above high water; range of river, or difference between high and low water mark, about 22 feet. No record of rafts passing this bridge has been kept. Number of boats passing and other data are given in Appendix K.

This bridge is situated at the foot of Des Moines Rapids, on which there is no place for a raft to tie up, so that the passage of the bridge must be attempted under any circumstances after leaving Montrose, at the head of the rapids. The left draw-opening and adjoining spans are used by rafts at all stages of water. During high water rafts can follow along the canal-bank on the right, the proper course to take for running these spans, but at low water they are obliged to follow the channel, which course brings them to the left bank about 1½ to 2 miles above the bridge, whence they cross through Sucker Chute to the right bank. The direction given to the raft by the current along the bank of the canal above the bridge is toward the piers to the left of the opening they attempt to make, and if, to avoid this, they hug the canal-bank to its lower end they come within the influence of the current setting in to the right draw-opening, and are then in danger of being carried against the draw-rest.

A sheer-boom, 1,200 feet long, should be extended from the pier to the left of the first long span from the draw, so placed that its upper end shall be 600 feet from the canal-bank, and a boom should be placed so as to connect the draw-rest with the lower end of the canal-walls.

The accompanying tracing, numbered 7, will show the position of the booms recommended.

RAILWAY-BRIDGE AT QUINCY.

This bridge was commenced in 1867 and completed in 1868, under an act of Congress approved July 25, 1866. It consists in all of 24 spans, 6 spans crossing Quincy Bay and 18 spans crossing the main river.

Draw-openings 160 feet wide, and raft-spans each side of draw. Bottom chord of bridge 10 feet above high water. Difference of level between high and low water mark about 20 feet.

Two hundred and eighty-three rafts passed this bridge during the rafting-season of 1876. The details are contained in Appendix L.

Rafts run in general the right draw-opening and adjoining span, the long spans to left of the draw not being available on account of a bar

which makes out from the left bank above the bridge. The bridge is also at the beginning of a crossing of the channel from right to left, and rafts are in consequence drawn toward the left piers of whatever openings they attempt to use.

A fixed boom 1,000 feet long should be extended up stream from the left rest-pier, its upper end 650 feet from the right bank. (See accompanying tracing numbered 8.)

RAIL AND HIGHWAY BRIDGE AT HANNIBAL.

Commenced in 1870 and completed in 1871, under act of Congress approved July 25, 1866. It consists of eight spans. Two of them are draws of 160 feet width of opening, and two are raft-spans; one next to right bank, with 215 feet available opening; the other to the left of draw of 240 feet. Bottom chord of bridge 10 feet above high water. Difference between high and low water about 22 feet.

One hundred and sixty-eight rafts passed this bridge during the season of 1875. The details are contained in Appendix M. Rafts generally run the right draw-opening and adjoining span. The velocity of the stream at the site of this bridge is so great that rafts cannot land within one mile above the bridge. During high water the rafts are split up and each part dropped through by the tow-boat. Allowing any portion of a raft to drift through is seldom attempted. The right bank just below the bridge is used by the lumber-dealers of Hannibal for landing their rafts, and rafts passing under the right span are liable to collide with them.

A boom 1,200 feet in length along, and its upper end attached to, the right bank, its lower end free to swing from the bank to the right rest-pier, should be placed above this bridge. (See accompanying tracing numbered 9.)

RAILWAY BRIDGE AT LOUISIANA.

Commenced June 23, 1873, and finished in December of the same year Built under acts of Congress approved March 3, 1871, and June 4, 1872. Consists of eleven spans of different lengths; two are draw-spans, each 200 feet wide, and one a raft span 250 feet in the clear. Bottom chord 10 feet above high water. Difference of level between high and low water about 20 feet.

The number of rafts passing this bridge is for—

1874	129
1875	109
1876 up to September 1	106

The details are contained in Appendix N.

At time of high water the draw-spans are used. During medium and low stages of water the right draw-opening is used. There is no place above the bridge for two miles, nor below it for three miles, where rafts can tie up. The locality is particularly exposed to winds. The draught of the current is along the right bank and in front of the landing above the bridge. In order to get into position for passing the draw openings, rafts are obliged to work to the left, and this has to be done by backing the boat, in order to give the rafts the proper direction.

The crib-work or bulkhead above the right rest-pier should be smoothed and extended up stream for 500 feet, and this line extended 820 feet farther by a fixed boom, its upper end 300 feet from the shore at ordinary low water. The extension proposed is delineated upon tracing numbered 10.

Wherever booms are mentioned above, floating structures are intended, and unless a fixed boom is specifically mentioned, a movable boom must be understood.

Sheer-booms should fulfill the following conditions:

They should be stable enough to resist the shock of colliding rafts and vessels without overturning, and should have strength sufficient not to break under impact at any point. They should not have a less draught than 30 inches, and should project above the water-surface at least 6 feet, in order to prevent the guards of steamers from passing over them and breaking their wheels. The submerged faces of the booms on the sheering side should be smooth, and the faces above water should be so arranged as to allow vessels to rub against them without injury to themselves or the booms, and the booms should, furthermore, fulfill their duties at all stages of water. All pivot-pier guards should be planked longitudinally from 30 inches below low water to 6 feet above high water, and these guards should include the pivot-piers, so that no projection of the latter should be exposed beyond the faces of the guards.

The Board in their recommendations have been confined to aiding the passage of rafts, and have considered the passage of steamboats only indirectly in so far as not to recommend anything for the former that would be detrimental to the latter. In several of the cases the importance of further protection to steamboats is more imperative than for rafts. The booms and other constructions recommended are regarded as but partial alleviations of the difficulties of raft-navigation, as the plans and locations of most of the bridges are such as to make any complete measures for the safety of navigation impossible.

As the Rock Island bridge is owned and operated by the General Government, a special appropriation by Congress of $15,000 will be required for the protection necessary, it being assumed that all the expenses attending the construction of booms, &c., at the other bridges, ordered by future legislation, will be borne by the owners of the bridges.

The accompanying drawings of portions of the different bridge-localities, upon which are indicated the positions of the booms and other works proposed, are taken from the maps made under direction of General G. K. Warren, Major United States Engineers, at different times since 1866, under an act of Congress approved June 23, 1866, which reads as follows:

> And for examining and reporting upon the subject of railroad-bridges across the Mississippi River between Saint Paul, Min., and Saint Louis, in the State of Missouri, upon such plans as will offer the least impediment to navigation of the river.

Full copies of these maps are on file at the office of the Chief of Engineers at Washington.

In addition to the appendixes noted above, others marked O, P, Q, R, S, T, U, V, and W, containing further information bearing upon the subject, are herewith forwarded.

A model of the Pond sheer boom, above referred to, is also forwarded.

We have the honor to be, very respectfully, your obedient servants,

J. N. MACOMB.
Colonel of Engineers, President of the Board.
J. H. SIMPSON,
Colonel of Engineers.
G. K. WARREN,
Major of Engineers and Brevet Major-General, U. S. A.
F. U. FARQUHAR,
Major of Engineers.
CHAS. R. SUTER,
Major of Engineers.
CHAS. J. ALLEN,
Captain of Engineers.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

W 3.

PROTECTION OF PUBLIC WORKS AGAINST TRESPASS OR INJURY.

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., January 13, 1877.

SIR: With the view to a compliance with the third section of the river and harbor act of August 14, 1876, which requires a report to Congress of all the instances in which piers, breakwaters, or other structures built by the United States in aid of commerce or navigation are used, occupied, or injured by a corporation or an individual, and the extent and mode of such use or injury, and the facts touching the same; and also what legislation is necessary to protect public works constructed by the United States against trespass or injury thereto, I instructed the officers and agents of this office in charge of public works to report all such instances within their knowledge, and also their views as to the legislation which would best prevent the evils in question.

It appears that, with the exception of the occupancy of the East Pier at Cleveland, Ohio, by the Pittsburgh and Cleveland Railroad Company, the terms of which are now being adjusted, there has not been to any serious or great extent injurious use or occupation of structures or works built by the United States to report to this office.

There have been instances of temporary occupation of piers as landing-places for cargoes which, by their weight, might injure the works; but in most cases the practice was discontinued upon notification.

There are instances of injury to piers from collision of vessels, from carelessness as well as from unavoidable causes.

There are also instances of willful injury arising from the pulling up of the deck-planks of wooden piers for the purpose of tying vessels.

There are instances of serious injury to navigable waters by the discharge of saw-mill waste into streams; also from booms for logs being placed in such a way as to seriously, and sometimes totally, impede navigation, and also instances of removal of stone from wing-dams, and of breaking openings through them for the passage of small boats or running of logs, thus rendering the dams incapable of effecting the object for which they were built.

There are instances of injury to water-gauges permanently established for the record of fluctuations of water surface.

In fair-ways of harbors, channels are injured from deposits of ballast, steam-boat ashes, oysters, and rubbish from passing vessels.

In some instances the local authorities have exercised a control over the public works in their vicinity, and in most cases the trespass or injury has been corrected upon notification.

So long as works are in progress and in charge of an officer or agent these evils are rare, but as they pass out of his hands they are at the mercy of evil-disposed persons, and it would be well under those circumstances to make it the duty of all officers of the Government, especially custom-house and revenue officers and light-house keepers, to report all cases of trespass or injury coming under their observation, either to their own department or to the nearest United States district attorney.

In many cases of harbor improvements on the lakes the Government has not acquired title to the land on which the structure is built, so that it is a question as to the right of the Government to prevent the use of the piers by the owners of the adjacent land and prevent them from having access to the stream. In the case of breakwaters isolated from

the shore, and resting on land owned by the United States, or State, the question of control is simple.

The object of these works being for the benefit of commerce, there should be no objection to their occupancy by private parties or corporations when finished, provided that the improvement of navigation for which they were built is unimpaired and the Government relieved of the expense of maintaining them.

A majority of the officers and agents of this office in charge of public works deem the penalty inflicted by the concluding paragraph of section 3 of the act of August 14, 1876, a sufficient protection, but it has also been suggested that its provisions should be extended so as—

1st. To cover all cases of trespass on United States grounds and structures.

2d. To cover all cases of negligent as well as willful injury.

3d. To cover not only river, harbor, and navigation works, but also all structures or marks established by the United States, so as to include all boundary-marks, tide gauges, stations, buoys, &c.

The special act of Congress (see vol. 18 Statutes at Large, part 3, p. 50) for the protection of the work in progress for the improvement of the navigation of the mouths of the Mississippi by dredging has proved defective, inasmuch as it requires proof of malice or intention, instead of simple proof of fact of injury or impediment to navigation.

In the case of the Louisville and Portland Canal, and at the Harbor of Refuge at Sand Beach, Lake Huron, experience has shown the necessity of some enactment to regulate the movement of vessels therein, to avoid danger to vessels and injury to the works. I have already, on the 29th February last, submitted a letter from Major Weitzel, Corps of Engineers, with inclosed form of an act which he recommends should be enacted by Congress for the government and control of this harbor of refuge. This was embodied in bill H. R. No. 2927 of last session of Congress.

To cover all cases of trespass and injury herein mentioned, and to conform as near as may be to the conditions required, I beg leave to suggest, as a modification of House bill No. 1079, of the last session of Congress, the inclosed form of an act which may cover all cases likely to arise, including the control of the Harbor of Refuge on Lake Huron, and of the Louisville and Portland Canal.

Very respectfully, your obedient servant,

A. A. HUMPHREYS,
Brig. Gen. and Chief of Engineers.

Hon. J. D. CAMERON,
Secretary of War.

FORM OF AN ACT TO PROTECT PUBLIC WORKS AGAINST TRESPASS OR INJURY.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it shall not be lawful to cast, throw, empty, or unlade, or cause, suffer, or procure to be cast, thrown, emptied, or unladen, either from or out of any ship, vessel, lighter, barge, boat, or other craft, or from the shore, pier, wharf, or mills of any kind whatever, any ballast, stone, slate, gravel, earth, rubbish, wreck, filth, slabs, edgings, sawdust, or other mill-waste of any kind, into any port, road, roadstead, harbor, haven, navigable river, or other waters of the United States, for the improvement of which Congress has already made, or may hereafter make, appropriations, or to deposit, or place, or cause, suffer, or procure to be deposited or placed, any ballast, stone, slate, gravel, earth, rubbish, wreck, filth, slabs, edgings, sawdust, or other mill-waste in any place or situation on shore where the same shall be liable to be washed into any navigable waters, either by ordinary or high tides, or by storms, or floods, or otherwise: *Provided*, That nothing herein contained shall extend or be

construed to extend to the casting out, unlading, or throwing out of any ship or vessel, lighter, barge, boat, or other craft, any stones, rocks, bricks, lime, or other materials used, or to be used, in or toward the building, repairing, or keeping in repair any quay, pier, wharf, weir, bridge, building, or other work lawfully erected or to be erected on the banks or sides of any port, harbor, haven, channel, or navigable river, or to the casting out, unlading, or depositing of any material excavated for the improvement of navigable waters, into such places and in such manner as may be deemed by the United States officer supervising said improvement most judicious and practicable and for the best interests of such improvements.

SEC. 2. That it shall not be lawful to build any bridge, bridge-draw, bridge-piers and abutments, causeway, or other works over or in any port, road, roadstead, haven, harbor, navigable river, or other waters of the United States, or to build any wharf, pier, dolphin, boom, dam, weir, breakwater, bulkhead, jetty, or other structure, outside established harbor-lines, or in such manner as shall obstruct or impair the navigation, commerce, and anchorage of said waters; or to excavate or fill, or in any manner to alter or modify, the course, location, condition, or capacity of the channel of said navigable waters of the United States, unless approved and authorized by the War Department.

SEC. 3. That all erections and works that are outside of harbor-lines, as now established, or that are so placed and constructed as to obstruct and impair the navigation and capacity of the navigable waters of the United States, or that it may become necessary to remove with a view to the improvement by the United States of such waters, shall be deemed a public nuisance and liable to indictment as such.

SEC. 4. That all wrecks of vessels, and other obstructions to the navigation of any port, roadstead, harbor, or navigable river, or other navigable waters of the United States, which may have been permitted by the owners thereof or the parties by whom they were caused to remain to the injury of commerce and navigation for a longer period than two months, shall be subject to be broken up and removed by the Secretary of War, without liability for any damage to the owners of the same.

SEC. 5. That it shall not be lawful for any person or persons to take possession of or make use for any exclusive purpose, build upon, alter, deface, injure, obstruct, or in any other manner impair the usefulness of any sea-wall, bulkhead, jetty, wharf, pier, or other work built by the United States for the preservation and improvement of any of its navigable waters, or boundary-marks, tide-gauges, surveying-stations, buoys, or other established marks; nor remove for ballast or other purposes any stone or other material composing such works.

SEC. 6. That every person, persons, or corporation offending against the provisions of this act shall, for each and every such offense, forfeit and pay a penalty of two hundred and fifty dollars, (one-half on conviction of the offender to be paid to the informer,) besides such further sum as may be found in any action for the recovery of the penalty or penalties incurred under this act to be the expense of making good the damage incurred, or of removing to a proper place the things deposited in violation of this act, such penalties to be recoverable by and in the name of the United States of America, with costs, in any circuit or district court of the United States, at the suit of any district attorney of the United States, or at the suit of any person, by information to any district attorney in any district where or near to where the offense shall have been committed or the offender shall be.

SEC. 7. That it shall be the duty of officers and agents having the supervision, on the part of the United States, of the works in progress for the preservation and improvement of said navigable waters, and, in their absence, of the United States collector of customs and other revenue-officers, to enforce the provisions of this law by giving information to the district attorney of the United States nearest to the place where any violation of any provision of this act shall have been committed.

SEC. 8. That the Secretary of War is hereby directed to assume full control over the Louisville and Portland Canal, at the Falls of Ohio River, and over the harbor of refuge at Sand Beach, Lake Huron, so far as may be necessary to control the passage through and use of those works; and he may establish such regulations as he shall deem needful to regulate the movement of vessels through and in them so as to avoid damage to vessels and injury to the public improvements at those places; and he will cause such regulations to be promulgated, by public notice thereof given in such newspapers as he may deem most suitable to give them the greatest publicity, and such regulations may in like manner be changed from time to time; and any person interfering with or obstructing, or attempting to obstruct, the free use of such improvement, in violation of the regulations aforesaid, shall be guilty of a misdemeanor, and, on conviction thereof, shall be punished by a fine of not exceeding five hundred dollars, or imprisonment for not more than six months, or both, at the discretion of the court.

W 4.

INVESTIGATION OF RAILROAD ACCIDENTS.

NEW YORK, *May* 14, 1877.

GENERAL: We have the honor to submit the following reply to your letter of 18th instant, transmitting to this Board "for consideration and suggestion, and such modification or amendment to the bill as it may see fit to propose,"

A bill to provide for the more thorough investigation of accidents on railroads,

together with a letter of Mr. T. C. Clarke relative to the inspection of bridges.

It appears from the remarks of Mr. Garfield, who introduced the bill in the House of Representatives, and from the letter of Mr. Charles Francis Adams, jr., who prepared the draught at the request of Mr. Garfield, that the scope of the measure has been purposely restricted, leaving to further legislation to expand the duties of the commission to any extent that practical experience may show to be needed. In this view of the matter, which is no doubt a wise one, the Board have no modifications or amendments to suggest, except that it would seem necessary to provide for an appropriation to meet the expenses which must be incurred in an efficient discharge of the duties imposed on the commission, and that it might be judicious to authorize the Secretary of War to instruct any engineer officer to assist the commission whenever deemed necessary.

This last suggestion is made with a view of saving time and expense by the occasional aid of engineer officers stationed at remote points of our vast territory. For example, should an unusual or calamitous accident occur west of the Nevada range, an officer in California could reach the scene of the calamity without much delay, whereas a week's delay in arriving at the locality of an accident might prevent the collection of reliable data in reference thereto.

To a full understanding of the state of this question of railroad accidents, and the means of preventing them, and as illustrating what, in our opinion, the scope of the duties of the proposed commission would be to attain the desired objects, the Board appends the following "memorandum," which was drawn up in the study of the subject.

The papers referred to the Board in connection with the subject are herewith returned.

Respectfully submitted.

J. G. BARNARD,
Colonel and Bvt. Maj. Gen.
Z. B. TOWER,
Colonel of Engineers, Bvt. Maj. Gen.
H. G. WRIGHT,
Lieut. Col. of Engineers, Bvt. Maj. Gen.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

MEMORANDUM TO ACCOMPANY REPORT OF BOARD OF ENGINEERS FOR FORTIFICATIONS OF MAY 14, 1877.

The bill proposed to constitute, by the appointment of the President of the United States, "a board of three commissioners, who shall be officers of engineers of the Army," the duties of which are defined as follows:

I. "To inquire into the number, causes, and means of prevention of accidents on

railroads in the United States, the number of persons killed thereby, and the most approved means of preventing the occurrence of the same."

II. "To hereafter investigate such accidents on railroads as may in their judgment be accompanied by circumstances of an unusual or unexplained character, and specially report upon the same."

Incidentally or supplementary to the foregoing duties, it is further provided—

III. "That in addition to all special reports from time to time made, the commissioners herein provided for shall at the close of each year forward to the Secretary of the Treasury a general report upon the subject of accidents upon railroads in the United States during that year.

Clauses II and III establish the fact that the "board of commissioners" is intended to be a permanent thing; that the "inquiry" provided for in clause I is not merely a single general investigation, but something to be perpetually maintained.

So far as the mere statistics of "accidents" are concerned, our technical journals give them with great thoroughness and detail. Turning, *e. g.*, to the "Railroad Gazette," we find (January 26, 1877) a summary of "Train Accidents" for the railroads of the United States for the years 1873, 1874, 1875, 1876; a recapitulation of which is as follows:

	1873.	1874.	1875.	1876.
Collisions	279	278	260	392
Derailments	655	840	654	815
Other accidents	48	83	66	76
	982	1,201	980	1,283
Average number per day	2.69	3.29	2.68	3.51

Collisions are subdivided into four categories, viz: "Rear Collisions," "Butting Collisions," "Crossing Collisions," and "Unknown."

Derailments resulted from no less than 35 special causes, such as "broken rail," "misplaced switch," "cattle on track," "wash-out," "loose or spread rails," "broken axle," "accidental obstruction," "broken wheel," &c.; those above named being the chief causes.

Other accidents, *i. e.*, accidents without derailment or collision, arose from 15 special causes, such as "boiler and cylinder explosions," "broken axle," "failure of bridge or trestle," "open draw-bridge," "accidental obstruction," "malicious obstruction," &c.

A more general classification of "derailment" accidents is as follows:

	1873.	1874.	1875.	1876.
Defects or failures in permanent way	200	146	261	165
Defects or failures in rolling-stock	73	63	101	76
Negligence, carelessness, or malice	96	107	114	119
Unforeseen obstructions, not malicious	111	109	142	107

In connection with which the remark is made by the editor, "*Negligence* would probably apply to many if not most of the cases of defects or failures of road and rolling-stock, as well as to the cases of misplaced switches, open draws, &c., to which we have applied it above."

In connection with the number of "accidents," given in first table, we have the following statements of the numbers of persons "killed and injured:"

	1873.	1874.	1875.	1876.
Killed	276	204	234	328
Injured	1,172	778	1,107	1,097
	1,448	982	1,341	1,425

And if we compare these figures with those which give the total number of *accidents* for the years, we shall find the average number *per accident* to be—

	1873.	1874.	1875.	1876.
Killed	0.215	0.209	0.195	0.334
Injured	0.914	0.800	0.923	1.117
Killed and injured per accident	1.129	1.009	1.118	1.451

With regard to the mere *statistics* of accidents little is left for a board to do. But it is doubtless the "means of prevention" that the bill has mainly in view, and especially the prevention of accidents to persons. The figures just given show that in general to one accident in *five* a life is lost, that somewhat more than *one* person is either killed or *injured per accident*, most of the *injuries*, however, being slight. Besides "accidents to trains" there occur accidents involving life or limb whether of passengers, train-

servants, or outsiders. Most of these are due to the carelessness of the sufferers; a considerable number, however, to inadequate precautionary measures for train management.

While the few *calamitous* accidents make strong impression on the public mind, and a recent one doubtless prompted the bill in question, the foregoing shows that in reality the ratio of injuries and losses of life occurring from them is but a small fraction of the total. Great as was the loss of life at the Ashtabula bridge accident, that calamity furnished but one-fourth to the number "killed" during the year, and the ratio of *calamitous* losses to the aggregate of *current* losses would probably be much less if taken through a series of years.

Inasmuch as personal injury and loss of life arise from almost innumerable causes, each referring itself back either to *inadequacy of construction or imperfection in management*, it is clear that the "means of preventing the occurrence of the same" involves the whole question of railway construction and management.

We believe that it would be in consonance with the maxims which prevail as to the functions of our General Government to leave this matter to the States in which our railways lie and the companies to which they belong to work out the desired results. Self-interest may be slow of sight, but it perceives at last what its own requirements are; while State legislation (the only legislation possessing jurisdiction) re-enforced by public opinion gradually *forces* railway directors to introduce, as proof shall be offered of their efficacy, all well-devised measures for safety of human life. The "board" contemplated by this bill could at best be merely *advisory*. That it should be such implies of course its *capability* of advising that it should be so thoroughly master of the whole subject that its advice would be sought and its authority on such subject *recognized*. Such sort of pre-eminence requires large experience and a minute knowledge of condition and defects and systems of management, &c., of the 75,000 miles of railway in the United States, and to some extent a similar knowledge with reference to the railways of Europe.

To obtain such information its sources would be—

1st. The journals or technical publications of the United States and Europe.

2d. Personal inspection by the commissioners or their agents.

3d. Correspondence and personal communication with engineers and managers of railways.

To carry out the above a considerable number of inspectors would be necessary, and a bureau or office with clerks wherein to collect information and compile the matter gathered. But *inspections* to be really such need not only the entire concurrence of the managers of the several roads, but an actual furnishing of facilities, (*i. e.*, special cars, &c.) We may well doubt whether the roads would generally furnish these facilities.

To carry out, therefore, with any efficiency the design of clause I, it would seem to us requisite besides creating a permanent board to add to it a considerable staff of assistants, and to establish a bureau for collection, compilation, and preservation of information.

The above refers to the most general construction of the duties (clause I) of the board.

Clause II, however, refers to accidents "accompanied by circumstances of unusual or unexplained character," including, doubtless, what we have called *calamitous* accidents, such as the Ashtabula bridge disaster. Such accidents are very few in number, (compared to totals of accidents,) and the loss to life and limb occasioned by them is, though relatively great but a small fraction of the total loss. Still such accidents, accompanied with circumstances of horror, impress strongly the public mind, and are in reality the main causes of a *sense* of danger in railroad traveling.

Moreover, while the daily small accidents refer themselves to hundreds of obscure causes, it is generally believed that these calamitous ones (when not the result of sheer negligence) refer to causes which intelligent investigation may develop, and for which there may be, or may be found, sure "means of prevention."

There are two main causes of calamitous accidents, viz: "collision" and "bridge failure;" to these might be added "open draw-bridges" and "derailment," but the "open draw" is so purely a matter of negligence that it may be referred at once to that head; while "derailment," though furnishing cause for about two-thirds of the "accidents," is rarely (though sometimes) decidedly calamitous. Its causes when thus calamitous differ little from its causes when not so. Wherever derailment is likely to cause great calamity (as on a bridge or high embankment) special precautions in running trains, and special means, are usually applied to prevent the accident or guard against disaster if it occurs. The absence of such precautions implies negligence which a subsequent investigation would doubtless bring to light.

Collisions constitute nearly one-fourth of total "accidents." They rarely occur without injury both to train and to passengers; and they are the most common source of calamitous loss of life. They may be said to depend *almost* exclusively on *management*. In this connection it is proper to remark that railway travel as it now is, really

is an almost new thing in the world. Forty years ago it was commencing its development. A few single-track roads in the United States, with strap-rails, connected then a few of our larger cities. The motion of trains was necessarily slow, their number small. With the development of railways over the whole country, and the rapid increase of travel, greater perfection of construction has been arrived at, and far more perfect *system* of train-management has become imperative. But these improvements have really (perhaps inevitably) lagged behind the demand for them. Nevertheless, their march has been real and rapid. The experience of the Centennial anniversary afforded proof of this. During the last three months of the Exhibition the trains on many roads were constantly overloaded, and frequently behind time, and on several they were multiplied to an extent never known before. The number of accidents, though somewhat increased, was not so in proportion to the traffic; the companies showing decided ability in adapting their operations to the emergency.

Methods for preventing collision on crowded roads have developed themselves *pari passu* with the need for them. The board of engineers which the bill proposes to organize could hardly collect information on this subject more thoroughly than it is now collected by the technical journals, nor would their advice or opinions weigh very heavily in the balance with those of the managers, engineers, and experts, whose occupation is one of constant experience of what is needed, of constant effort to supply the need, and who through their own professional societies have means of consultation and comparison of results.

There remains one source of calamitous accident to treat, one which apparently does *not* so immediately refer itself to the comprehensive head of railway management, and this is the one classified as the "failure of bridges."

In our early railway construction we contented ourselves with bridging the smaller streams by wooden structures of short spans, the larger navigable ones being crossed by boat ferries. The development of the railway system and the increase of traffic has compelled the filling of these gaps by bridges, some of which, through the exigencies of the case, involving very long spans. Such spans can only be made with iron; moreover, this material has been gradually substituted of late years for the existing early constructed wooden bridges. But for this iron construction, the knowledge of the material itself, and of the means of preparing it, of working it into required forms and of combining it into masses, was not itself fully developed. Both for the manufacturer and engineer there was a vast and almost unexplored field. Congress has recently recognized the importance of aiding one branch of this exploration by the creation of the board appointed March 25, 1875, "to test iron, steel, and other metals," &c.

In the other branch—the engineering—the demand for long-span bridges has taxed the efforts of engineers for suitable methods, which have not yet had time to establish their claim to recognition as *best*.

We need only refer to the letter of Mr. T. C. Clarke, the head of an iron-bridge building firm, well known in the United States and Canada for the extent and excellence of its work.

According to Mr. Clarke's opinion, "Your board of commissioners should, as soon as possible after their appointment, meet at Washington and take evidence from engineers, particularly those expert in bridge construction, and establish upon the basis of that evidence certain general rules to apply to all bridges, both railway and highway, such as—

"1. The least load to be provided for on different length of spans and on parts of the same span.

"2. The margin of safety.

"3. The mode of connecting the parts together, so as to form a whole as strong as the parts.

"4. Such mode of construction as would best prevent deterioration and decay. All of this could be expressed in such words as would, while not hampering the skill of designers, yet greatly increase the public safety.

"These rules should be published and communicated to the different authorities, State, municipal, and railway, with the authority and prestige of the board. More than this I do not feel competent to recommend; but as an engineer and constructor of iron bridges, I do say that inspection should—

"1st. Be made by independent parties.

"2d. Should cover all kinds of bridges.

"3d. Should be under a uniform system based on evidence taken from experts. Your board would largely increase its usefulness if it covered the last two points."

The foregoing would make the board not merely an investigator of "accidents," but a central authority on the subject of bridge-building. There is doubtless great diversity of opinion, or at least lack of means on which to base authoritative rules on the several points numbered 1, 2, 3, 4 by Mr. Clarke. While on the one hand the board would have no authority to call for, and no means (without an annual appropriation for the purpose) to defray the expense of procuring evidence, we are not prepared to say that the proposed

board might not do much useful work in the way indicated. On the other hand, these questions involve the whole problem of bridge-building—a problem, as it now presents itself, for great span railway-bridges, yet not definitely solved, and which must to a certain extent work out its own solution. A central board of engineers might doubtless aid this progress and conduce to "public safety" by collecting data and furnishing temporary "rules" founded thereon.

That it should do so requires that its members besides being generally scientific engineers, should be thorough masters of the theory and practice of railway-bridge building.

But it seems to us that Mr. Clarke's recommendations go beyond the scope of the proposed bill, which *primarily* has reference to accidents and their means of prevention, and, *secondarily*, to investigation of accidents "accompanied by circumstances of unusual or unexplained character," (referring doubtless to the breaking down of bridges, as well as to other calamitous accidents.)

Generally speaking, *collisions* are the prolific source of calamitous accidents, those from failure of bridges in 1876 numbering but 20, against 280 collisions, and some 600 derailments from other causes. And the remark is called for that the small bridges rather than the great ones are the source of danger. The latter are always designed with great care, and the plans subjected to severe testing, their faithful construction secured by close supervision, their preservation insured by systematic watchfulness, and the running of trains over them subjected to severe regulation. The frequency of accidents from breakage of trestles and small bridges is due to the great number of these small structures, and to their eluding in some degree the precautions which conduce to the safety of great bridges. They, therefore, to that extent are due to the prolific source of railway accidents, "negligence," and must owe their prevention to the introduction of more vigilant and systematic management, the necessity and *true economy* of which is now being realized by our railway authorities.

We regret that we are not able to describe the systems of government supervision of railways and bridges by the European governments. That there is to some extent an authoritative supervision in France, Germany, Austria, and Russia is believed. A thorough knowledge of these systems would be very important in its bearing upon measures our own Government should desire to adopt.

We here confine ourselves to an exhibition of the full bearings and scope of the proposed measure. It involves questions of *policy* of the Government in this relation, and it seems to us that secured co-operation of the several State governments would be very desirable to insure its full efficacy.

LETTER OF MR. THOMAS C. CLARKE, CIVIL ENGINEER.

PHILADELPHIA, *March* 19, 1877.

DEAR SIR: I have received a copy of your proposed bill regulating inspection of bridges, and have been requested to communicate my views to the American Society of Engineers for discussion at their April convention at New Orleans. I have done so, and I now take the liberty to send you the views which I have given them.

I believe that inspection should be done by independent parties—that it should be general, covering all kinds of bridges, and that it should be under an uniform system.

Your bill recognizes the first requisite. It, however, covers accidents on railways only. The truth is, that as far as bridges are concerned, those on railways are much better watched and are safer than highway bridges, which have in most cases no inspection at all. I would insert after the words United States "and from the falling of highway bridges."

The most important requisite is that inspection of bridges should be made according to one uniform system. As it now is, the State legislatures, under the spur of the panic derived from the Ashtabula disaster, are framing laws providing for inspection under different systems, and with different penalties.

Your board of commissioners should, as soon as possible after their appointment, meet at Washington and take evidence from engineers, particularly those expert in bridge-construction, and establish upon the basis of that evidence certain general rules to apply to all bridges, both railway and highway, such as—

1. The least load to be provided for on different lengths of spans, and on parts of the same span.
2. The margin of safety.
3. The mode of connecting the parts together, so as to form a whole as strong as those parts.
4. Such mode of construction as would best prevent deterioration and decay.

All of this could be expressed in such words as would, while not hampering the skill of designers, yet greatly increase the public safety.

These rules should be published and communicated to the different authorities, State, municipal, and railway, with the authority and prestige of the board. More than this, I do not feel competent to recommend. But as an engineer and constructor of iron bridges I do say that inspection should—

1. Be made by independent parties.
2. Should cover all kinds of bridges.
3. Should be under an uniform system based on evidence taken from experts.

Your board would largely increase its usefulness if it covered the last two points.

I am, very respectfully, your obedient servant,

THOMAS C. CLARKE,
Member American Society Civil Engineers and Institution of Civil Engineers, London.

Hon. JAMES A. GARFIELD, *M. C.*

[44th Congress, 2d Session, H. R. 4558.]

A BILL to provide for the more thorough investigation of accidents on railroads.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the President of the United States is hereby authorized and requested to appoint a board of three commissioners, who shall be officers of engineers of the Army, to inquire into the number, causes, and means of prevention of accidents on railroads in the United States, the number of persons killed or injured thereby, and the most approved means of preventing the occurrence of the same; and it shall be the duty of said commissioners to hereafter investigate such accidents on railroads as may, in their judgment, be accompanied by circumstances of an unusual or unexplained character, and specially report upon the same.

SEC. 2. That the commissioners appointed under this act shall, in addition to their pay as officers of engineers of the Army, receive compensation for actual travel and other necessary expenses incurred in the duties herein designated.

SEC. 3. That in addition to all special reports from time to time made, the commissioners herein provided for shall, at the close of each year, forward to the Secretary of the Treasury a general report upon the subject of accidents upon railroads in the United States during that year; which report, together with any special reports which the commissioners may have made during such year, shall be submitted to Congress.

INDEX.

INDEX.

INDEX.

INDEX.